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## ERRATA

See paper by R. Milton (January, 1945), *An Absorptiometric Method for the Estimation of Atmosphere Benzene.*

*Page* 36, column 1, 5 lines from bottom: *instead of* "not more than 5 mg." *read* "not less than 5 mg."

*Page* 37, column 2, third para, line 4: *instead of* "to which is added 30 ml. of absolute alcohol," *read* "to which is added 3·0 ml. of absolute alcohol."

# HEALTH PROBLEMS IN THE MERCHANT NAVY

BY

G. JAMESON CARR

*London*

Before the present war, in July 1939, the gross tonnage of the mercantile shipping of the British Empire amounted to 24¼ millions, or some 30 per cent. of the world's tonnage. The United States of America came next with over 12 million tons; followed by Japan, 5½ millions; Norway, 4¾ millions, Germany, 4½ millions; and France and the Netherlands each just under 3 million tons. The shipping industry has contributed more to our prosperity than any other single industry, yet the personnel did not exceed 180,000 before the war. The large majority of these men are employed in ships without surgeons. This fact is relevant in that the conditions under which surgeons are required may explain the fact that, up to date, the medical profession has had little opportunity to influence health conditions amongst merchant seamen. Surgeons are only appointed under the Shipping Act where over 100 persons are on board, or when there are over 50 emigrants. So it is obvious that seamen in the majority of ships below 10,000 tons and with less than 100 on board—and these constitute perhaps 75 per cent. of the total tonnage—are mainly dependent upon first-aid treatment at the hands of captains or stewards.

The growth of reasonable amenities and good conditions of employment in the Merchant Navy—the Mercantile Marine—has always been slow. Public opinion has played little part in their development, largely because of the lack of knowledge on the part of non-seagoing persons. As in other industries established before the middle of last century there is a long record of exploitation. But man-power was never lacking. Wretched quarters, the scanty and sometimes bad rationing, and cruel beatings, did little to deter men from the sea. Even to-day there is no established supervising medical authority to advise on crews' quarters, diet, ventilation, lighting and other matters concerned with health. Enterprise in this respect is a matter for individual owners who for the most part restrict themselves to strict regulations under the Act. Until recently the only means of communication between various countries was by water, and that still remains the chief method of transport of heavy merchandise. This is likely to be even more important in the future.

The sea as a calling is the most hazardous of all large group activities, except perhaps that of the soldier on active service. Before the change from sail to steam the mean annual death rate of 64 per 10,000 in the British Mercantile Marine was five times greater than that of other hazardous industries such as coal-mining and quarrying. This figure has now been reduced to 19·9 per 10,000 (1937), but is still in excess of the rate in coal-mining and quarrying which lies between 11·5 and 12·5 per 10,000. The figures during this war are not available, but Table 1 shows the loss of life amongst U.K. merchant seamen from 1935 to 1937.

TABLE 1

LOSS OF LIFE AMONG MEMBERS OF THE CREWS OF U.K. MERCHANT VESSELS, 1935–37

| Year | No. employed | | Deaths due to accident * | | Deaths due to disease, homicide or suicide* | |
|---|---|---|---|---|---|---|
| | British only | Including foreign subjects and Lascars | British only | Including foreign subjects and Lascars | British only | Including foreign subjects and Lascars |
| 1935 | 126,700 | 182,500 | 265 (20·9) | 323 (17·7) | 268 (21·1) | 467 (25·6) |
| 1936 | 130,830 | 185,970 | 190 (14·5) | 236 (12·7) | 322 (24·6) | 499 (26·8) |
| 1937 | 133,110 | 190,690 | 265 (19·9) | 328 (17·4) | 281 (21·1) | 464 (24·3) |

### Catastrophes and Accidents at Sea

Catastrophic events at sea may be caused in the following circumstances: collision with icebergs; collision with ships; grounding on rocky coasts with heavy seas; and fire. In addition, many accidents of a minor nature may be expected, such as injuries to passengers and crew through ship hit by heavy seas causing bodily injuries to persons on board; seamen falling from aloft or down holds; explosion in boiler compartments; and injuries by contact with moving machinery.

The risk of collision with icebergs has lessened considerably since the *Titanic* disaster on April 14, 1912, when the ship foundered after hitting an iceberg, causing the deaths of 1595 passengers and crew—711 persons being rescued. The advent of the International Ice

* Figures in brackets indicate the rate per 10,000.

Patrol in the ice season, together with the development of continuous wireless watches on shipboard, has enabled shipping to be fairly accurately informed of the presence of dangerous ice, though the combination of ice and fog usually found in the danger area is still a menace which can never be overlooked. Collision with ships is a danger which occurs in all parts of the world, especially in those latitudes where fog is prevalent. Here again the hazard is becoming less owing to the universal use of wireless, and the fact that in all ships of modern design the crews are no longer 'housed' in the forecastle where impact usually takes place. Grounding on rocky coasts in heavy seas is less common during recent years due to the use of modern navigational appliances such as Fathometers, directional wireless and submarine signalling apparatus. Storm, fog, ice and fire are, therefore, the greatest menaces at sea and often entail unavoidable death and injury. Obstacles to rescue are sometimes insuperable: it has been impossible to launch lifeboats or to pass life-lines even where rescuers are more than willing to risk their own lives. Inaccessability, or being out of range, may also be a serious obstacle to succour. The accurate charting of the seas has resulted in well-defined sea routes for all ships except those engaged in exploration and adventure, so now there are few occasions when a ship is completely outside the sphere of aid.

Certain hazards affect all ships alike whether large or small, but the personnel and equipment required to contend with them is not the same. For instance fire-fighting equipment in modern ships of large tonnage is highly efficient; not only are ordinary fire extinguishers provided and $CO_2$ cylinders for holds, but there is 'Foamite' for oil in the engine-room, and an automatic thermostatic system of sprinklers through the ship. In addition there is the Richardio, the latest method of fire-alarm signalling. Fire alarm stations are manned day and night; alarms and signals are led by wire pipes and telephone to the bridge; and from here all valves are coupled to $CO_2$ bottles in stores, holds, baggage and mail room. The modern lifeboat is now motor-driven, and in the event of abandoning ship freezing is prevented by thermostatic methods of electrical heating and starting. One latest device is the gravity davit for launching lifeboats. For prevention against grounding the Echometer or Fathometer determines water depths with great accuracy. The present war has been responsible for the invention of devices which make a most remarkable contribution to life-saving from hazards formerly considered as irreducible. For example the Loran, used for long-range navigation by wireless rays from coast stations, works by beam interception and actually plots the position of the ship at any time or place in the course of a vessel crossing an ocean, and the Asdic, an instrument which detects objects under water, has a range of several miles.

## Medical Personnel

Board of Trade inspectors and Lloyds' surveyors are appointed to see that the statutory regulations are observed; they do not make recommendations, neither do the Board of Trade medical inspectors. Port Health Authorities are eminently qualified to make recommendations on health conditions for seamen but lack the necessary authority to do so. So it rests with those companies with initiative and an enlightened sense of obligation to the seamen to suggest and improve conditions such as crews' quarters. As long as their improvements do not interfere with the safety of the ship they meet with no objection from the Board of Trade.

The ship surgeon is one of the persons who should be most active in this respect. He should make recommendations on all matters of hygiene and health, but in practice he rarely does so except in minor matters and chiefly with regard to his own sick bay and medical equipment. Above all others he should be competent to criticise and recommend improvements, but the fact is that he is rarely qualified to do so. Unlike conditions of service in the Merchant Navy of at least three other nations the British ship surgeon is not required to attend courses in ship hygiene and other relevant subjects. He learns mainly by experience, and is effective in his work only if he happens to be interested in the sociological and preventive aspects of this branch of industrial medicine. So it is vitally important that properly authorized schemes of training be set up wherever possible under the aegis of a University. Schemes of training would apply, in the main, to permanent ship surgeons—only about 300 in peace-time, but a sufficient number nevertheless to warrant action being taken at the earliest possible opportunity. Although over 1000 other ships employ temporary surgeons, voyage by voyage, it is unlikely that these doctors would be willing to undergo special training before employment, nor indeed would it be necessary.

The Board of Trade appoints medical inspectors of ships, whose duty is 'to inspect the medicines, medical stores and antiscorbutics with which a ship is required by this part of the Act to be provided.' The Board also appoints medical inspectors of seamen. By this part of the Act application is made by the master of any ship for a medical inspector to examine any seaman applying for employment. Medical inspectors are also appointed to inspect steerage passengers and crew about to proceed in emigrant ships. In this capacity the inspector is required by the Immigration Officer 'to see that none of the crew or steerage passengers appear to be, by reason of any bodily or mental reason, unfit to proceed or likely to endanger health or safety of the other persons likely to proceed in the ship.'

The Board of Trade also requires that 'every foreign-going ship having 100 souls on board shall carry on board as part of her complement some duly qualified medical practitioner'—the ship surgeon. In Sect. 303 of the Shipping Act the following instruction is found: 'A duly authorized medical practitioner shall be carried on board an emigrant ship when the number of emigrants exceeds 50; and also where the number of persons on board (including cabin passengers, officers and crew) exceed 300.' The person authorized to ratify the appointment of both ship surgeons and medical

inspectors is the Emigration Officer, a layman. Here is an example of the need for revision.

### Hospitals and Sick Bays

'The spaces set apart for hospital accommodation shall be on or above the uppermost passenger deck and shall be properly divided off from other living quarters to the satisfaction of the emigration officer and the Board of Trade medical officer at the port of construction or clearance.'

These are the regulations for ships carrying doctors. All liners are furnished with hospitals for passengers and crew which are fairly adequate. Space allotted for this is usually far in excess of Government requirements. But the isolation hospital is still being housed on the aft poop, where the thrashing of propellers and the pitch and roll in bad weather are hardly conducive to the rest and quiet of a fevered patient. In any case there is no scientific evidence to show that infectious patients require that extreme measure of isolation, and in a few modern ships their accommodation adjoins the general hospital. On most liners there is a departure from regulations where hospitals are housed midships below decks.

In freighters—ships from, say, 1000 to 10,000 tons—which are not required to carry a surgeon, our British practice falls behind that of some other nations. There is no statutory requirement for a sick bay. Some, but not many, enlightened companies do provide this; but it is rarely adequate nor is it well placed. Infectious cases were and are frequently isolated by placing them in the lifeboats and long usage of such practice has blunted the sensibility not only of owners but of the men themselves. Attempts to administer first-aid treatment in the restricted surroundings of the crews' quarters in the forecastle are commonly ineffective. Imagine the plight of a man with a fractured femur in such surroundings, or the man with pneumonia where posture and complete rest are equally imperative; here they are submitted to the maximum movement of the ship, to the incidental noises of winch and chain, to the disturbance caused by change of watch and to a smoke-laden atmosphere. If the provision of permanent quarters is impracticable then the ships should be so planned as to permit the conversion midships of a room which might, when not in use for patients, be used for storage. In large freighters the example of the U.S.A., Norway and Australia might be followed; they arrange permanent quarters for a sick bay with accommodation according to numbers. But in existing small ships even this requirement may be impossible. In all new ships some change is imperative; there must be convertible quarters for small ships, and a sick bay for larger ships with beds in proportion to numbers of crew.

### Problems of Smaller Ships

In the big liners there are adequate hospitals and the medical personnel includes one, two or even three doctors, with dispensers, male hospital orderlies and nurses in addition. Here conditions are good, both for medical staff and crew. But there is a large number of cargo ships—comprising all varieties of craft from coasters to foreign-going ships up to 10,000 tons—whose total tonnage far exceeds that of ships required to carry surgeons and with good amenities. These present a real problem. The facilities for first aid vary widely from ship to ship, but for the most part they are inadequate. Some ships may have doctors, but the great majority do not and we have seen that here there is no statutory requirement for sick-bay accommodation. It is as arbitrary to conclude that all ships below 8000 tons are without surgeons as it is that all above do employ them, but this represents a good basis for discussion. This large number of ships is split up into small, independent and almost isolated groups, and makes uneconomical in most of them the employment of a doctor and all that that appointment entails—assistants, equipment and a sick-bay. A similar problem is also found in the smaller factories and group activities ashore, but with this profound difference: skilled medical attention is, almost everywhere ashore, quickly available for any emergency. That is why first aid afloat assumes an importance peculiarly its own; first aid, in fact, may mean the only aid and therefore extends to routine treatment. For that reason the service of first aid at sea demands most careful scrutiny. Accidents on board ship, in themselves, present no more unusual feature or problem than those encountered ashore. But the skill, intelligence and experience of the man rendering first aid, owing to the unusual locus and the difficulty of obtaining early professional assistance, is a matter of signal importance.

Our immediate and present concern should therefore be directed to improving the medical facilities for foreign-going freighters which comprise 75 per cent. of our tonnage. The coasters have their own problems, but except in unusual circumstances, aid is within their easy reach; in most countries they have always shore stations at their service through wireless communication, and these can readily provide for all medical contingencies. The number involved is, in any case, relatively small. Whatever reforms are suggested must be practicable and easy to enforce, and must win the co-operation of owners. The financial outlay can readily be justified by greater efficiency. Changes must be acceptable to crews and, if possible, uniform throughout the shipping world despite the difficulty of language.

Freighters are required to carry certain drugs and stock mixtures and medical stores according to Scale II of the Shipping Act,* itself a document of much interest—to the medical historian. Masters are required to have the St. John or St. Andrew

* Some of the drugs itemized in the Captain's Medical Guide are: alum, amyl nitrate, pulv. digitalis, lot. hydrarg. nig., creosote (for dental caries), liq. plumb. subacet., tr. opii, pot. bromide, pot. chlor., sulphur. rotund., and ung. ac. boric. Frequently these drugs may have to be administered by laymen, and more often than not insufficient directions are given, nor is there adequate instruction in their use,

Ambulance Certificate. The captain in ships without surgeons is regarded as the person responsible for the sick and injured man. This has a formidable disadvantage since in times of emergency he must first attend to the safety of his ship. It is therefore the custom for him to delegate his medical obligation to one of the officers, or more usually to the steward. It has been suggested for any foreign-going ship that a petty officer might be appointed to do this duty or some other rating, usually unspecified, who would combine this duty with others. In any real emergency however the only rating in a small crew who could be spared and diverted to this duty is the steward, and the chief objection is that he is wholly untrained for this post. He receives instructions from the captain but is allowed no responsibility; he has to refer to the captain when in difficulties, and this is not a commendable procedure in a time of emergency at sea. It is therefore suggested that in ships with no doctor the master should be relieved of all direct responsibility for medical and surgical care of the sailor. The steward on such ships could well be given this responsibility on the condition that he undergoes a three months' course on lines similar to those for sick-berth attendants of the Royal Navy.* The 'Pool' system would make it easy for such a man to attend these courses.

There is another alternative. Retired Royal Navy sick bay petty officers might be offered the opportunity to undertake this work. This rating is of proved value in other types of industry, in factories for instance, as a member of the medical service provided, and in passenger ships he is invaluable. To get over the difficulty of adding a new rating to small ships he might undergo a course in stewardship. Less objection would be forthcoming from the freighter companies if they were not required to make an addition to their personnel, for reasons of space and finance. The institution of a special diploma for Merchant Navy sick-berth attendants is a possibility. There may be objections to this but its possession would at least imply a certain amount of education and intelligence, without which it would be impossible to understand and follow out instructions at sea provided in an up-to-date Medical Manual. A new Manual, comprehensive and up to date is essential. If possible it should be on an international basis.

### Pre-employment Medical Examination

As a preliminary to any recommendations being made about the treatment of the merchant seaman it must be remembered that to sign on an unfit man, or a partially disabled man, is to contract a wholly unnecessary liability. The medical and personal problem is complicated by his presence on board. Engagement of a crew therefore becomes a matter of much importance and is the intimate concern of preventive medicine. The man with heart disease, nephritis, epilepsy, venereal disease or chronic rheumatism, or with disablements such as hernia, varicose veins or flat feet may, in the event of any major catastrophe, be a definite embarrassment and even a menace in a small ship's company. His condition may in certain circumstances be such as to precipitate a catastrophe, and his presence on board is often fiercely resented by his mates. A primary requisite, therefore, of any improved health service is an adequate system for ensuring pre-employment examination, including chest radiography.

*Effects of the Merchant Navy Pool.* As this war developed the demands of both industry and the fighting service threatened the man supply of the Merchant Navy. The Pool in the first instance was intended as a source of man-power. If some measure had not been taken to hold men to their sea service by a shore subsistence wage many of them would have drifted into the fighting services or the factories. The periods in port when loading and unloading ships and for repairs, involve shore idleness of crews from days to weeks. The Essential Work (Merchant Navy) Order, 1941, established a definite service which men could not leave except for bad health, disablement or serious misdemeanour.

In order to provide fit men medical examination centres were established at certain large ports. There all applicants for service in the Merchant Navy are medically examined, except those who are being engaged by shipping companies which prefer to select and examine their own men. But there are certain defects in this system and these need amendment. After the first examination for the Pool a man may have various illnesses. Because of the lack of follow-up examination at definite intervals these frequently develop unknown to the authorities or, it may be, to the man himself. Only in the event of discharge from a ship for sickness or disablement (and in the event of that man being signed off the Pool), or where a man ashore is called up and reports to the Pool obviously ill, would there be a note inserted on the health record. The high mortality rate due to sickness (see Table 1) is, like the accident mortality rate, evidence of failure to eliminate applicants quite unfitted for the sea. The Pool as it is fails to obtain reliable information or morbidity rates; and so it enables the doctor to do little by way of prevention of ill-health.

### Crews' Quarters

One of the most important health provisions for merchant seamen is adequate living quarters in the ship. Overcrowding in quarters is a potent factor in the spread of disease. Wood (1942) has shown that seamen arrive for treatment for tuberculosis in a more advanced stage of the disease than do the

* At the Royal Naval Hospital at Chatham, for example, he could obtain suitable instruction including tuition in hygiene; he could work in the hospital to get practical experience in the dressing of wounds and burns, and the management of sick and injured men in the wards. Points to be stressed would be the importance of posture in the treatment of fractures and dislocations, the significance of dyspnoea in acute conditions such as pneumonia, the meaning of oedema, the avoidance of bed sores, and the nursing of unconscious patients. There would be instruction in the methods of administering drugs, injections, enemata and of passing catheters. Some knowledge of invalid cookery would be most important.

FIG. 1 (above).—Living quarters in a British-owned ship built in 1924. Here the crew eat and sleep. There is no separate mess-room accommodation. Note food strewn about the bunks.

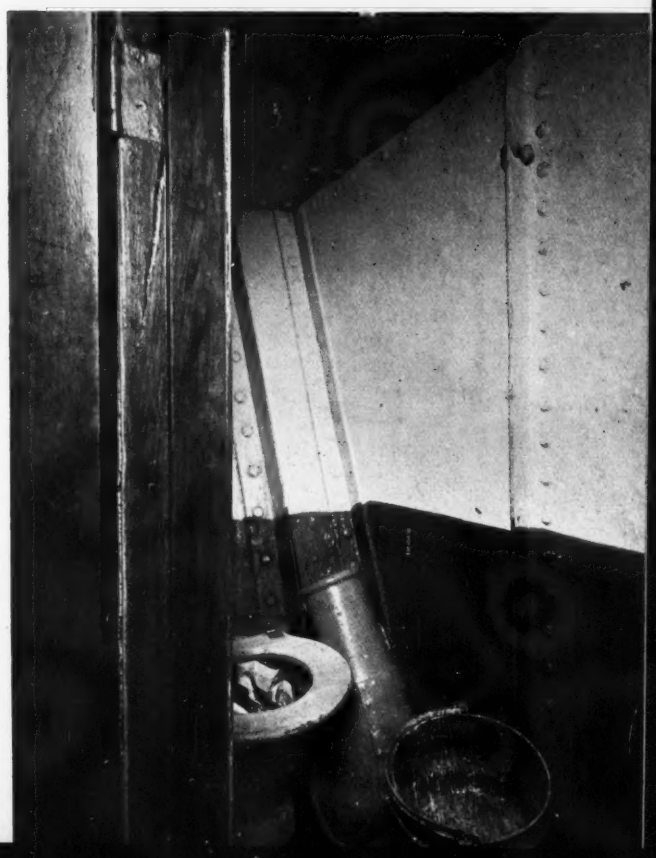


FIG. 2 (right).—W.C. accommodation in the same ship. The bucket is for washing in. There are no wash-basins available.

FIG. 3 (above).—A typical picture of the average conditions in a modern British cargo vessel. Here is the sleeping accommodation in a four-berth cabin.

FIG. 4 (below).—Washing and W.C. accommodation in the same ship. Note lack of privacy. The wash-basins have only cold salt water laid on.

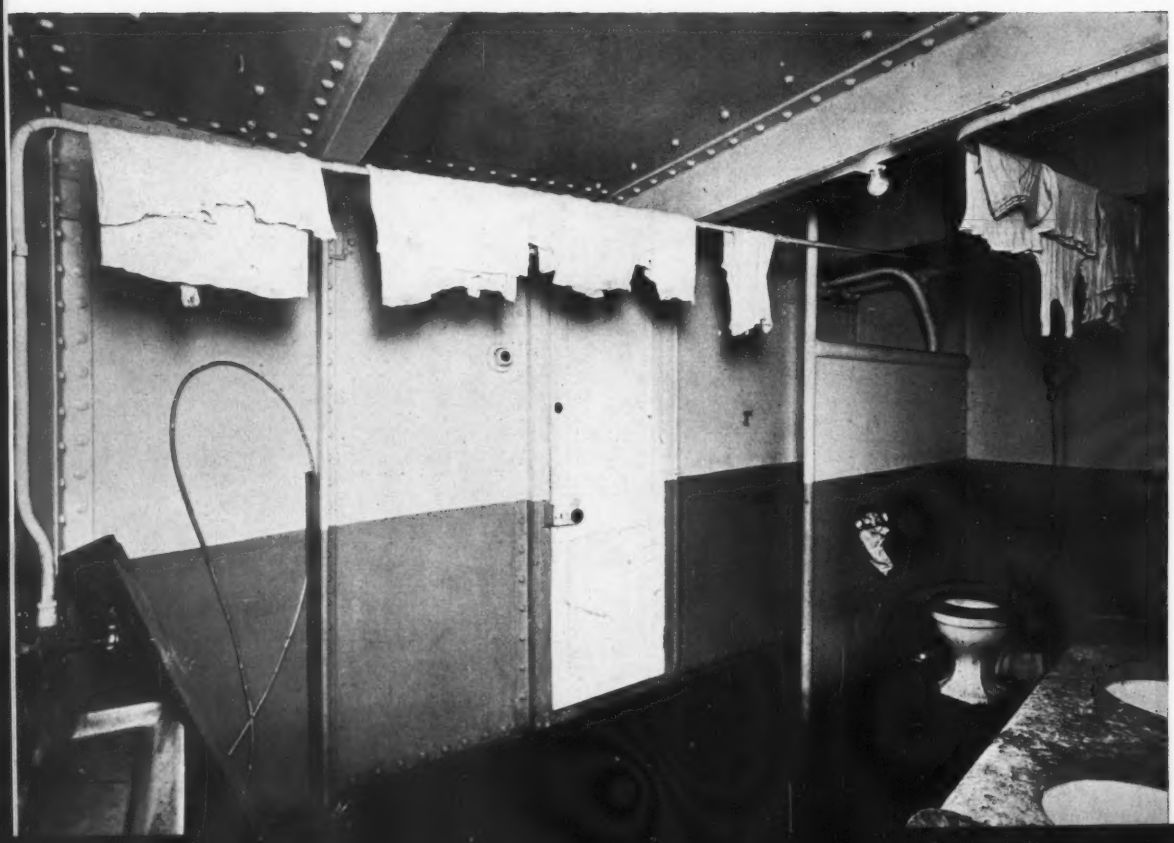
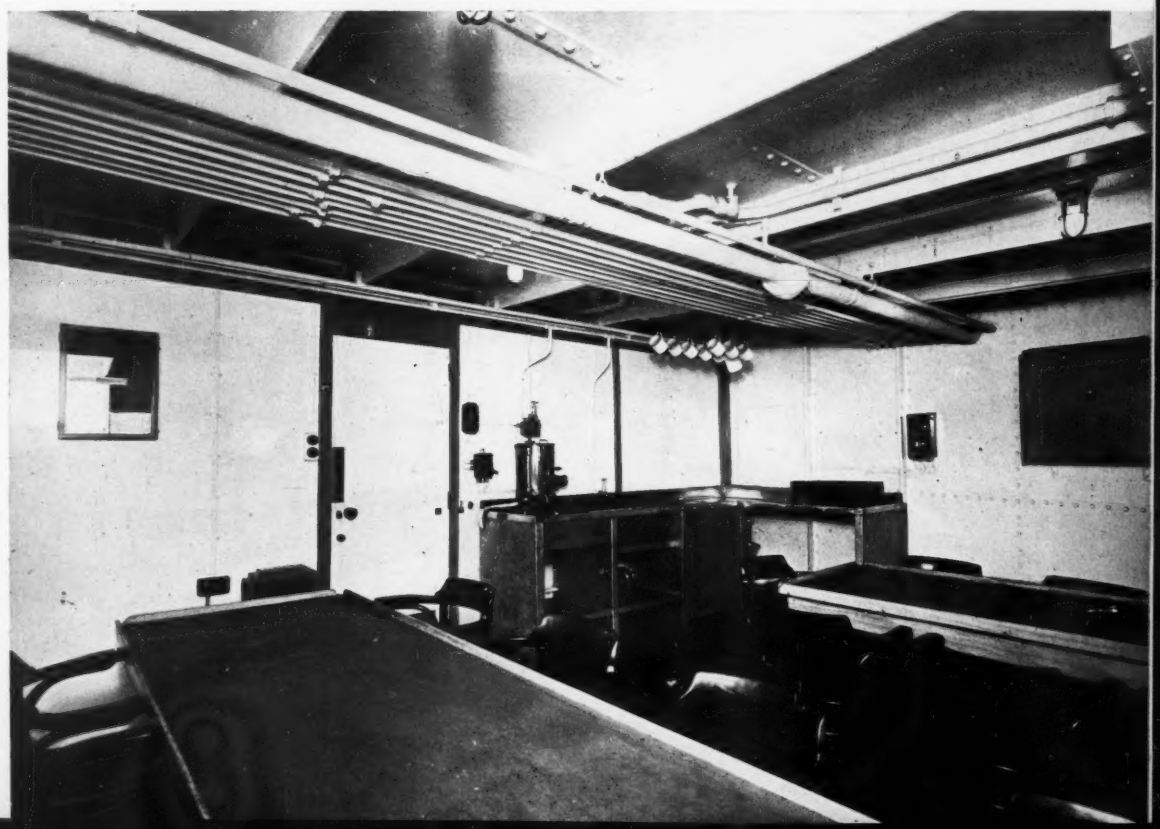


FIG. 5 (above).—A two-berth cabin in a British cargo vessel built in 1936. These are standard for all the seamen on board. Note the full-length locker for each man. There is an obvious impression of cheerfulness.

FIG. 6 (below).—The mess-room in the same ship. Each man has his own chair instead of backless forms found in 99 per cent. of ships.



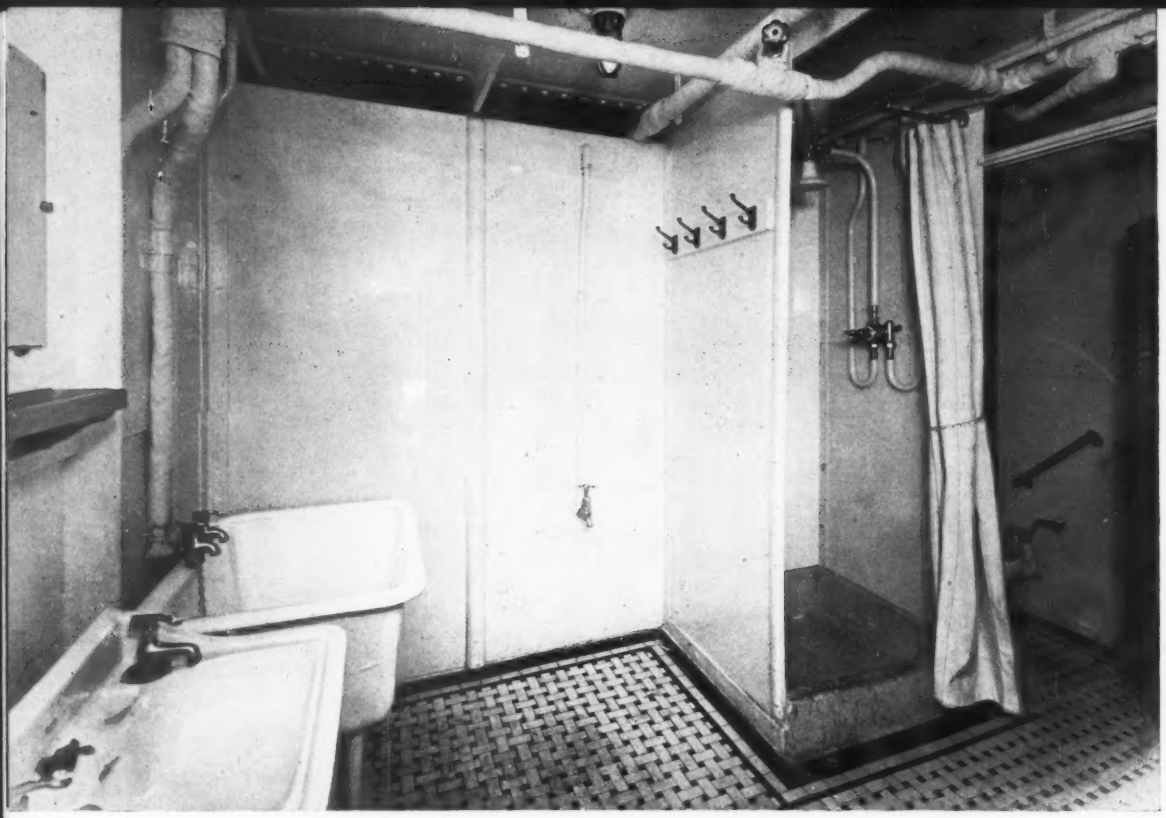
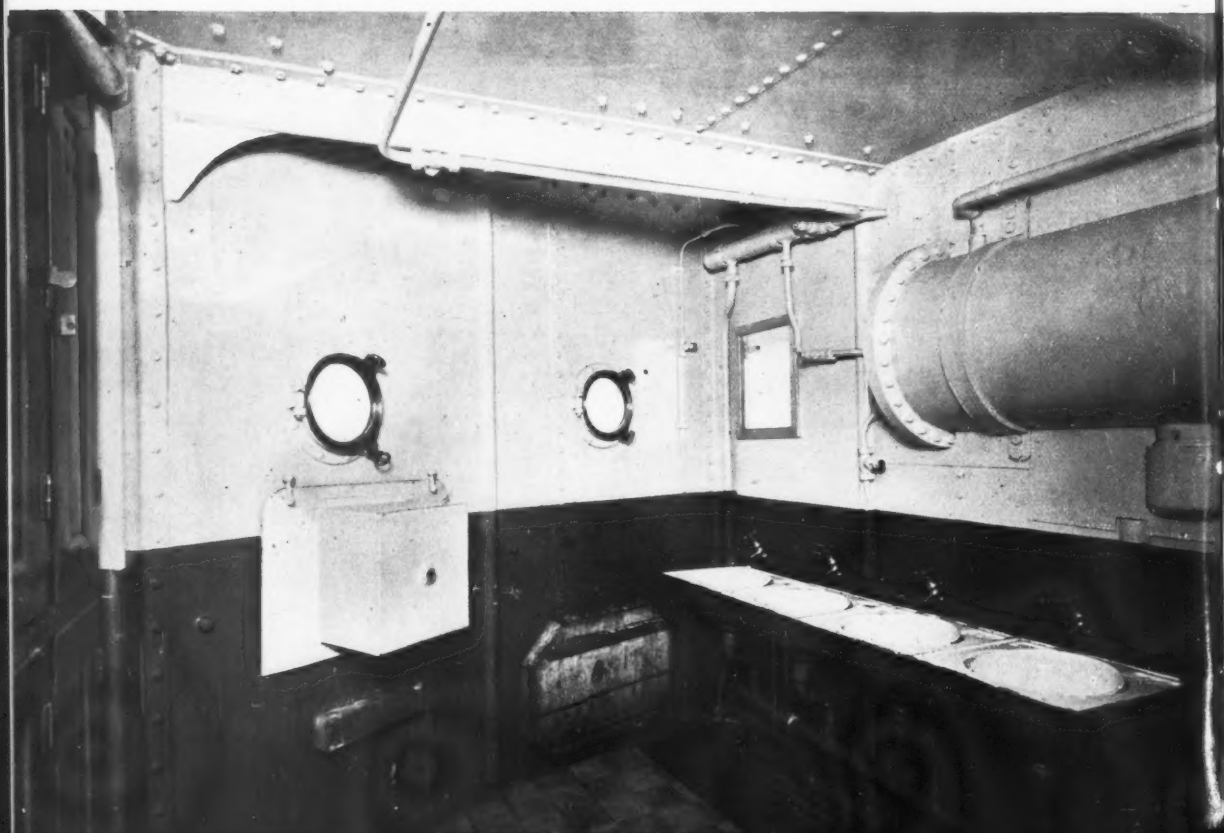


FIG. 7 (above).—Washing and bathing accommodation for the crew in the same ship as Fig. 5. These are ideal and could not be improved. Hot and cold fresh water always available. Curtains provide privacy.

FIG. 8 (below).—Washing accommodation in a foreign-owned ship. Hot and cold fresh water always available The large tank above the basins contains 800 gallons of electrically heated water with thermostatic control.



general population. He considers that unsatisfactory living conditions at sea, and overcrowding in particular, are a main reason for this. Earlier diagnosis could be achieved by routine radiography. Frazer (1936) in a report to the Liverpool Port Sanitary Authority points out that much can be done by competent inspection to improve conditions. In Liverpool all vessels entering the port are visited as soon as possible after docking. Quarters are inspected and inquiries made on matters such as the health of the crew during the voyage, the source of the water supply, the condition of tanks and bilges and whether any sick or dead rats have been found. Unsatisfactory conditions are reported in writing to the captain. Black (1945) has surveyed the problem of crew accommodation in the Merchant Navy. During 1942 and 1943 he examined in detail the quarters provided in 60 British merchant ships for 1857 seamen. He found that ships built since 1937 provide better quarters than those built previously; in some cases they were excellent. But in some of them the regulations of the Board of Trade were being loosely enforced. The improvements most needed are an increase in the space standard in sleeping quarters, and some scheme whereby plans for quarters in new ships should be passed by a medical officer with experience, before construction is started. Illustrations of both good and bad quarters are given in figs. 1–8.

### Communication by Wireless

If the captain of a ship with no doctor is in some medical difficulty he sends out a wireless message in the hope that he may get advice or even personal aid from another ship carrying a doctor. This method of communication is now simplified by the use of code. In the International Code of Signals 1931, the medical section includes three parts: quarantine; case-taking system; diseases and description of condition. The case-taking system at a first glance seems formidable, but is a simple and clear method of sending a message in order to get a medical opinion. If the instructions in its use are carefully followed the necessity for cross-questions and answers will be largely eliminated. Communication between alien tongues is through associated code words but has frequently given rise to absurd misunderstandings. There is still some difficulty with regard to the advice that may be given owing to the lack of international agreement on medical technical matters. The metric system, for example, is not yet universal. Advice on specific treatment cannot be given through the Code, so the only alternative at present is to give a diagnosis and refer the captain or his deputy to his own Medical Guide. This unsatisfactory state of affairs will remain until international agreement is reached on the various points which have been raised in this paper.

### Summary and Conclusions

Adequate methods of training ship surgeons should be provided. This is part of the development of industrial medicine and should be University responsibility. At the present time the ship surgeon has little interest in preventive and social medicine. He should pay special attention to the hygiene of the ship, for example crews' quarters.

The majority of ships in the Merchant Navy have no surgeon, so in such cases specially trained first-aid attendants should be provided. If necessary they should also act as stewards. Courses of training for sick-berth attendants should be instituted, and ex-R.N. personnel considered where appointments are being made.

Pre-employment medical examination in the Merchant Navy is essential and should be developed to include measures such as chest radiography. It must also include an adequate follow-up scheme.

Special attention to matters such as sick-bay space and site, crews' quarters, mess-rooms, lavatory accommodation, ventilation and lighting, should be paid by ship builders in the future. All plans for new ships should be scrutinized by a competent medical authority.

There is need for a new Maritime Medical Manual, international in scope. Drugs, instruments, and other medical equipment in ships should be brought up to date. Methods of communication on health matters at sea should be simplified and improved.

### Acknowledgement

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# SOME EARLY EFFECTS OF EXPOSURE TO TRINITROTOLUENE *

BY

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It was felt that if we could determine the early effects of exposure to TNT, the later manifestations of severe poisoning, which occur in only a small percentage of people, might be better understood. In order to overcome the difficulties inherent in a large scale survey of factory workers, we decided to use volunteers who would be willing to work for a period in a filling factory and co-operate in a series of tests in Oxford before and immediately after the period of exposure. In this way we could try out an extensive series of tests and select those which would be most useful and practicable in subsequent investigations of the ordinary factory worker. Permission was obtained from the Ministry of Supply, and an appeal was made to the undergraduates of Oxford and several other Universities to spend part of the summer vacation doing their work. The number of volunteers easily exceeded the number that could be dealt with in the laboratory or conveniently handled at the factory. In the end 62 students were chosen. Physical examination and laboratory tests showed that all of them were healthy.† They went to the same Royal Ordnance Factory and were housed in one of the government hostels for factory workers. They had no special privileges and were treated as ordinary workers, receiving the same rates of pay and obeying the same rules and regulations. They were asked to stay a minimum period of four weeks and many stayed longer.

### Description of Factory Work and Grouping of Students

Contact work for 42 of the students was done in the filling shops. In addition ten male students spent part of their time in the melt houses. An analysis of the concentrations of air-borne TNT in the shops where the students were working was made for us by C. G. Warner‡ and the figures obtained are given in Table 1. If the students were taken off contact for any reason, usually because of dermatitis, they worked on trucking, fusing trench mortars, or in the stores. Fig. 1 shows the length of time spent by each individual in the different shops. There were two day shifts, each of which lasted 8 hours, with a canteen interval of half an hour in the middle, and one night shift of 9½ hours, with two shorter rest periods. There was a week-end break which varied from 18 to 36 hours according to the shift. The students wore the regulation overalls and caps, worked with bare hands and did not wear masks. In the statistical analysis of the data it was found desirable to subdivide the total population of students into three groups, which were homogeneous as regards sex and occupation. Group I (44 females) and Group II (8 males) worked in the filling shops, and the average exposure in both groups was 33 days. Group III (10 males) averaged 18 days in the filling shops and 15 days in the melt houses.

TABLE I

CONCENTRATION OF AIR-BORNE TNT IN FILLING SHOPS AND MELT HOUSES

| Contact work | Av. conc. of TNT in mg. per cu. metre | |
|---|---|---|
| | Day | Night |
| Filling shops .. .. | 0·3 | 0·6 |
| Melt houses — | | |
| Floor .. .. | 0·3 | 0·3 |
| Platform .. .. | 1·2 | 1·3 |

The average age in all three groups was twenty years. The results for the three groups are given separately in the tables which follow.

* Report of an investigation carried out during the summer of 1942 at a Royal Ordnance Factory, under the auspices of the Medical Research Council.

† One of the female students had had catarrhal jaundice 3 years before. There were no signs of hepatic impairment at the initial examination and she experienced no ill effects from working at the factory except a slight anaemia, the haemoglobin falling from 89 to 80 per cent.

‡ Method described at the Medical Research Council Conference on TNT., 1942.

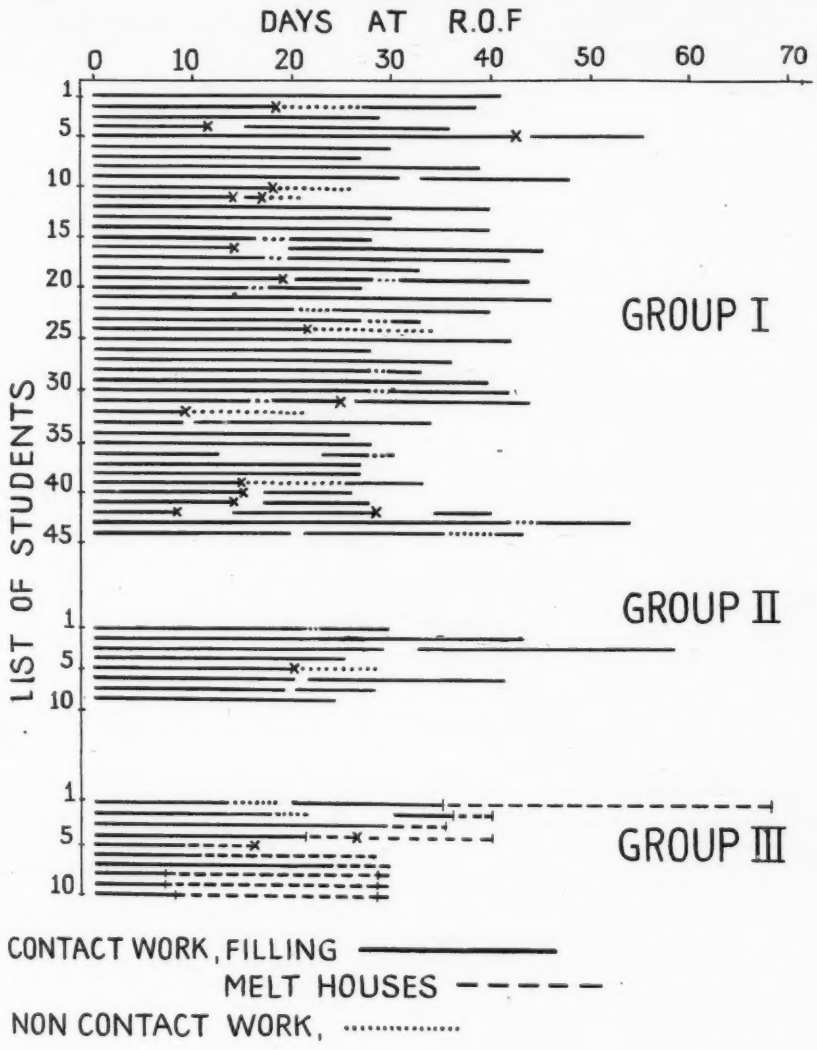
DAYS AT R.O.F
0 10 20 30 40 50 60 70
LIST OF STUDENTS
1 5 10 15 20 25 30 35 40 45
GROUP I
1 5 10
GROUP II
1 5 10
GROUP III
CONTACT WORK, FILLING
MELT HOUSES
NON CONTACT WORK,
× TAKEN OFF CONTACT FOR REASONS OF ILL HEALTH OR RASH

FIG. 1.—Duration of exposure to TNT and type of work done by 62 students at a Royal Ordnance Factory.

Before going to the factory, the volunteers spent two days in Oxford, where everyone was given a full clinical examination which included records of blood pressure, weight and urine analysis. On the afternoon of the first day they had a 4-hourly hippuric acid test. The following morning the students returned fasting to the laboratory and 20 c.c. of venous blood was collected in an oxalate tube. Samples from this single collection were used for the following tests:

Red blood cell count
Haemoglobin
Haematocrit
Blood urea
Plasma bilirubin
„ cholesterol
„ proteins
„ phosphatase

A sample of capillary blood was collected for white cell count and reticulocytes. Immediately afterwards the student was given 100 gm. of sucrose (cane sugar) in 200 c.c. water and samples of venous blood were collected at the end of one, one and a half and two and a half hours, for determination of blood laevulose. On the afternoon of the same day most of the students visited the Oxford Nutrition Survey where their dark adaptation was tested and their eyes examined with the slit lamp, and a further sample of blood was collected for the following examination:

Vitamin C in plasma and white cells
Cocarboxylase
Riboflavine
Vitamin A and carotene

While the students were at the factory reticulocyte counts were taken every third or fourth day and the

TABLE 2

SUMMARY OF THE CLINICAL FEATURES. TNT SICKNESS INCLUDES VOMITING, ABDOMINAL PAIN, NAUSEA AND DIARRHOEA. MISCELLANEOUS SYMPTOMS INCLUDE NASAL AND THROAT IRRITATION, FATIGUE, MENSTRUAL DISTURBANCES AND OEDEMA

| Students | | | Exposure | | | | Symptoms | | | | | | | | | | | Weight | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Days | | | Rash | | | | TNT sickness | | | Cyanosis | | | | | |
| | | | | | | | | Hands only | | | | | | | | | | | |
| Group | Number | Sex | Operation | Average | Maximum | Minimum | Generalized | Severe | Moderate | Slight | Severe | Moderate | Slight | Severe | Transient | Miscellaneous | Hunger | Before | After |
| | | | | | | | | | | | | | | | | | | lb. | lb. |
| I | 44 | F | Filling .. | 33 | 56 | 9 | 3 | 3 | 5 | 14 | 2 | 10 | 12 | 0 | 0 | 16 | 40 | 143 | 140 |
| II | 8 | M | Filling .. | 33 | 54 | 20 | 0 | 1 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 3 | 8 | 140 | 135 |
| III | 10 | M | Filling .. | 18 | 31 | 8 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 1 | 4 | 10 | 9 | 142 | 142 |
| | | | Melting .. | 15 | 30 | 3 | | | | | | | | | | | | | |

urine was examined at frequent intervals for urobilin. A selected number collected 24-hourly urines for estimation of porphyrins, and samples were also examined for indican, and the Webster and Kennedy-Ingham reactions. These tests were repeated after leaving the factory. On two occasions research workers paid a visit to the factory to collect a batch of blood samples at the end of a shift for methaemoglobin estimations.

On return to Oxford the tests and clinical examinations were repeated. A careful history was taken, recording the exact number of days on contact, the work done, and the development and duration of symptoms. During the experiment it became apparent that haematological changes were occurring and the last three volunteers agreed to have a sternal puncture before and after exposure. This investigaton was also made on two other individuals at their final examination, and was repeated three months later. Finally, a few individuals who had experienced abdominal pain were asked if they would submit to a gastroscopy, and four volunteers were examined in this way (three women and one man).

The following technical methods were used:

BLOOD

*Haemoglobin*

(1) Carboxyhaemoglobin method of Haldane (British Standards Institution, No. 1079, 1942).

(2) Alkaline haematin, colorimetric (Clegg and King, 1942).

(3) Pyridine haemochromogen, colorimetric (Rimington, 1942).

(4) Total iron, dry ashing and titanous chloride titration (Klump, 1934).

*Reticulocytes*

Supravital cresyl blue (Kracke, 1941).

*Urea*

Urease and nesslerisation (Archer and Robb, 1925).

*Laevulose*

Laevulose was determined in the blood before and after the ingestion of 100 gm. of sucrose by mouth (Higgins, 1942). The method of estimation is colorimetric (Patterson, 1935). The *laevulose index* was obtained by subtracting the fasting value of the blood laevulose in mg. per 100 c.c. from the values at 45, 90, 120 and 150 minutes after giving the sucrose, and adding together the figures so obtained (cf. Galactose Index, Barnes and King, 1943).

*Methaemoglobin*

Spectro-photometrical (Vigness, Watson and Spink, 1940).

PLASMA

*Proteins*

Micro-kjeldahl (Howe, 1921).

*Bilirubin*

Total bilirubin, modified Van den Bergh, colorimetric (Thanhauser and Anderson, 1921).

Direct and indirect bilirubin, photometric (Malloy and Evelyn, 1937).

*Phosphatase*

Colorimetric (King and Armstrong, 1934).

URINE

Hippuric acid test (Probstein and Londe, 1940).

Kennedy-Ingham test. Colour reaction (Kennedy and Ingham, 1942).

Webster test. Colour reaction (Webster, 1921).

Coproporphyrin. Fluorimetric and U.V. absorption (Jope, 1942).

DIRECT INDICAN REACTION. Among tests for the presence of abnormal substances in the urine was included the reaction for indoxyl potassium sulphate (indican). After the period of exposure a certain number of urines gave a direct indican reaction; that is, the addition of concentrated hydrochloric acid without the oxidizing agents usually used in the tests for indican, caused the formation of indican. This reaction was carried out in the following manner: 2 ml. of chloroform were placed in a graduated centrifuge tube, 5 ml. of urine were added followed by 5 ml. of concentrated hydrochloric acid. The tube was corked and shaken vigorously to ensure extraction of indigo by chloroform. If a blue colour developed in the $CHCl_3$ within 5 minutes, the test was considered positive. With most of the urines which gave positive reactions, the formation of indigo occurred within 1 to 2 minutes of addition of the acid. Often urines gave a positive reaction on standing for a greater length of time and those urines which gave an immediate positive reaction gave more intense reactions on standing. It is advisable to ignore these later reactions, since the concentrated hydrochloric acid may produce slowly oxidizing substances from the urinary constituents. An explanation of this immediate indican reaction is that nitro compounds, simultaneously excreted with indoxyl potas-

sium sulphate, act as oxidizing agents in the same way as the hypochlorites in the usual indican tests. A similar explanation has been offered for the direct indican test given by pellagrin's urines. (Meiklejohn and Kark, 1939.)

**The Findings**

The symptoms and clinical effects experienced by the students from work in contact with TNT were identical, not only in nature but also in frequency, with those recorded by Voegtlin in 1922 and by Noro in Finland in 1941. All the students were re-examined six months later and none showed any ill effects from the experiment.

GASTROSCOPY. Four of the students who had experienced gastro-intestinal disturbances were examined with the gastroscope on their return from the factory. Symptoms in two of them had appeared early. In both there was epigastric tenderness and deep pressure in the right hypochondrium had brought on a recurrence of the pain. The other two had had no symptoms until after five weeks' exposure, but pain and nausea had been present for at least two weeks. Abdominal examination in these two was essentially negative. The gastroscopic findings were similar in all four cases though they varied somewhat in severity. In each case there was an excessive amount of thick, ropy mucus which was adherent to the gastric mucosa. The latter was slightly paler than normal and had an a slightly smooth appearance. These changes were more marked in one case with severe symptoms than in the other three, and in this individual the gastric surface showed numerous high lights suggestive of oedema and excessive mucus. The resting juice was examined in each case and free acid was present. The changes observed are those commonly seen in mild cases of so-called catarrhal gastritis.

URINE TESTS. The urine of all the students was tested at the initial and final examinations in Oxford, and morning specimens were tested once a week while at the factory. Thirty-one students collected 24-hourly specimens before, during and immediately after exposure. The latter were used for estimation of coproporphyrin excretion and in addition certain special tests were carried out—Webster reaction, Kennedy-Ingham and direct indican reaction. These tests were repeated on all the urines at the final examinations. The routine examination included tests for albumin, sugar, acetone and urobilin.

At the initial examination a trace of albumin was found in two cases and acetone in one. No one had either sugar or urobilin. The urine tests carried out at the factory and on returning to Oxford gave a positive urobilin test in twenty-six students. Often it was only present on one occasion but in several it was found in two or more instances. Usually the test was a slight positive, but in seven cases it was strongly positive. Only one person (in Group III) had bile in the urine. A trace of albumin was found on one occasion only and acetone was present once in three individuals.

The coproporphyrin estimations gave figures within the accepted range of normal in every instance. The Webster test was positive in twenty-nine individuals, the Kennedy-Ingham in forty-two and the direct indican in eighteen. The Webster test has for long been accepted as an indication of absorption of TNT and is of no special pathological significance, though observers have commented on the fact that it becomes negative in cases of toxic jaundice. In this investigation, where the test was often repeated as many as four or five times in the same individual, it was frequently positive on one occasion and negative on another. The same variability was noticed in the Kennedy-Ingham reaction. The significance of the latter is not yet clear, but the original claim that a positive colour reaction indicated an increased excretion of coproporphyrin in the urine is not borne out by the present investigation as there was no correlation between it and the direct coproporphyrin estimations. There was no difference in the number of positive Webster and Kennedy-Ingham tests in the three groups, and no correlation with the clinical findings.

Indican (potassium indoxyl sulphate) is an important ethereal sulphate derived from the products of intestinal putrefaction and a positive test for indican in the urine is usually taken to indicate some intestinal disorder or an excessive ingestion of meat in the diet. In the present series fifteen of the eighteen individuals with a positive direct reaction had symptoms of TNT sickness. It should be noted, however, that the urine from normal individuals may occasionally give this reaction.

HAEMATOLOGY. The haemoglobin was checked by four independent observers, each of whom used a different method: (1) Total iron. (2) Haldane (standardized by N.P.L.). (3) Alkaline haematin. (4) Pyridine haemochromogen. For conversion into percentage values, 15·0 g. haemoglobin was made equivalent to 100 per cent. The values recorded in Table 3 are the average of all four methods in each case. There was a fall in haemoglobin, red cells and haematocrit reading in all three groups of students. The average percentage fall was slightly greater for the haemoglobin than for the erythrocytes but the alteration in colour index was negligible. The changes were greatest in Group III, especially in the haemoglobin values. In each series there was considerable variation in the individual results. In Group I the maximum fall in haemoglobin was 28 per cent., whereas seven cases showed a change of less than 4 per cent. and one had a rise of 8·5 per cent. In Group II the greatest individual drop was 23 per cent.; one case showed no change and one gave an increase of 10·5 per cent. on his original figures. In Group III every case gave a lower value after exposure and the drop ranged from 10 to 21 per cent. in every case except one where the fall was only 4 per cent. Similar variations were found in the red cell counts and the haematocrit percentage. Over 80 per cent. of all the students were adversely affected.

TABLE 3

BLOOD STATE BEFORE AND AFTER EXPOSURE TO TNT

In this and the other tables the mean values and the standard error of the mean are shown for each of the three groups of students. Where the figure after exposure is significantly different (i.e. the probability of error less than 1 in 100) it is in italics.

| Investigations | Group I (44 females) | | | Group II (10 males) | | | Group III (8 males) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference |
| Haemoglobin, per cent. .. .. | 94±1·1 | *84*±1·0 | −9·7±1·06 | 105±3·3 | 95±2·15 | −9·5±3·4 | 106±1·55 | *91*±0·88 | *−14·2*±1·5 |
| Erythrocytes, × $10^6$ per c.mm. .. | 4·9±0·07 | *4·6*±0·07 | *−6·2*±1·58 | 5·4±1·43 | 4·9±1·43 | −9·2±3·4 | 5·5±0·1 | 4·9±0·1 | −10·5±1·4 |
| Haematocrit, per cent. .. .. .. | 41±0·59 | *39*±0·48 | *−4·9*±1·15 | 47±1·28 | *43*±1·36 | *−8·5*±3·1 | 48±1·17 | *43*±1·13 | *−10·0*±2·07 |
| Reticulocytes, × $10^4$ per c.mm. | 3·8±0·78 | *9·3*±2·17 | *+140*±1·67 | 3·6±0·75 | *12·6*±2·6 | *+250*±0·7 | 4·3±0·83 | *27·1*±5·5 | *+530*±1·47 |
| Leucocytes, × $10^3$ per c.mm. .. | 7·4±0·33 | 5·8±0·41 | *−22*±3·96 | 6·2±0·64 | 6·1±1·1 | −2±18·3 | 6·8±0·66 | 8·0±0·74 | +18±13·1 |

Accompanying these changes there was an increase in the number of reticulocytes in the circulation. Reticulocyte counts were made at the beginning and the end of the experiment, and also every two or three days at the factory. For statistical purposes absolute values have been used rather than the more usual percentages. The average initial figure for all three groups was 40,000 per c.mm. and the normal range may be taken as 20,000–60,000 per c.mm. The increase was much greater in Group III than in either Group I or II, and in this group the average final value was over seven times the original. In Groups I and II the increase was approximately three times the mean initial value. Again the individual variation was considerable, and in Group I seven cases had a final count of less than 70,000 per c.mm. In Group III half the cases had counts of over 200,000 per c.mm. with a maximum of 530,000 per c.mm., and no one had a count of less than 70,000 per c.mm. In Groups I and II the maximum values were 290,000 per c.mm. and 260,000 per c.mm. respectively.

The final reticulocyte values recorded in Table 3 were those obtained on return to Oxford, 24–48 hours after leaving the factory. In almost every case this value was higher than any obtained during the period of exposure. The complete set of values obtained in one case (No. 47, Group III) throughout the period of exposure and for the four weeks following is given in Fig. 2. The last reticulocyte counts at the factory are compared with the values on return to Oxford in Table 4. The counts

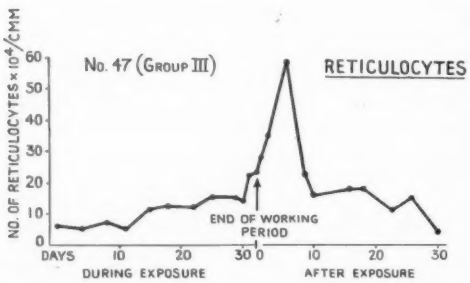


FIG 2.—Total reticulocyte count during and after heavy exposure to TNT, showing crisis after removal from contact.

TABLE 4

LAST RETICULOCYTE COUNT AT FACTORY COMPARED WITH VALUE ON RETURN TO OXFORD APPROXIMATELY 48 HOURS LATER

| Group | Reticulocytes Average number per c.mm. blood (× $10^4$) | | |
|---|---|---|---|
| | Before exposure | Last count at factory | Two to four days after cessation of contact |
| I | 3·8 | 7·5 | 9·3 |
| II | 3·6 | 8·1 | 12·6 |
| III | 4·3 | 15·0 | 27·1 |

at the factory in Groups I and II were only just outside the normal range.

The findings in the five sternal punctures are summarized in Table 5. One was a man from Group II and four were men from Group III. In all the cases from Group III the marrow, after exposure, was very cellular and showed a marked erythroblastic reaction. The nucleated red cells frequently occurred in nests and mitotic figures were very apparent. The number of erythroblasts showed an average increase of three times the resting value. The appearance of the marrow before and after exposure was essentially unchanged in the only case from Group II that was examined. This individual had shown no evidence of destruction of the circulating red cells.

METHAEMOGLOBIN. Blood from seventeen students was examined for methaemoglobin before departure, and the pigment was uniformly absent. Nine of these were re-examined at the factory, the blood being drawn immediately after the end of a shift. Three from Group I were all negative, two from Group II gave values of 0 and 3 per cent. respectively, while four from Group III all gave positive results ranging from 3 to 6 per cent. Five others were examined on their return to Oxford. The interval between collecting the blood and leaving the factory in these cases varied from thirty-six to sixty hours. The results in four of these (three from Goup I and one from Group III) were negative. The remaining one was a man from Group III who had developed severe anilism.

TABLE 5

RESULTS OF STERNAL PUNCTURE IN FIVE STUDENTS EXPOSED TO TNT

| Sex | Group | Per cent. erythroblasts in sternal marrow | | | Haemoglobin, per cent. | | Reticulocytes, $\times 10^4$ per c.mm. | |
|---|---|---|---|---|---|---|---|---|
| | | Before exposure | Immediately after exposure | 3 months later | Initial | Final | Initial | Final |
| M | III | — | 46 | 14 | 115 | 94 | 4·6 | 50·0 |
| M | III | 10 | 31 | — | 100 | 96 | 7·7 | 38·0 |
| M | III | — | 33 | 20 | 99 | 89 | 6·1 | 52·8 |
| M | III | 16 | 35 | — | 116 | 93 | 3·4 | 44·1 |
| M | II | 23 | 28 | — | 86 | 92 | 6·0 | 5·3 |

TABLE 6

RESULTS OF LIVER FUNCTION TESTS (Cf. legend to Table 3)

| Investigation | Group I | | | Group II | | | Group III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference |
| Total serum bilirubin, mg. per 100 ml. .. | 0·38±0·03 | 0·51±0·06 | +36±12·1 | 0·75±0·24 | 1·51±0·51 | +134±67·5 | 0·45±0·009 | 1·19 ±0·32 | +179±90·0 |
| Indirect bilirubin, mg. per 100 ml. .. | 0·2 ±0·003 | 0·3 ±0·02 | ±85±50·9 | 1·0 ±0·72 | 1·4 ±1·3 | + 40±50·0 | 0·2 ±0·07 | 1·35 ±0·96 | +410±311·0 |
| Direct bilirubin, mg. per 100 ml. .. | 0·3 ±0·003 | 0·3 ±0·02 | 0±50·9 | 0·5 ±0·72 | 0·6 ±1·3 | +20±50·0 | 0·2 ±0·07 | 0·4 ±0·96 | +100±311·0 |
| Plasma phosphatase, units .. .. | 7·3 ±0·25 | 8±0·45 | +9±1·69 | 9·8 ±1·03 | 11·9±2·9 | ±21±33·5 | 8·3 ±0·76 | 10·1 ±1·0 | +21±13·6 |
| Hippuric acid test, per cent excretion in 4 hours .. .. | 88±1·04 | 87±1·21 | −1±1·16 | 93 ±0·68 | 87±2·6 | −6±3·4 | 93 ±1·37 | 91±1·5 | −2±2·46 |
| Laevulose index .. | 21±2·03 | 23±1·74 | +9·5±4·2 | 22 ±2·7 | 20±1·29 | −9± 7·8 | 21 ±1·42 | 20±1·08 | −5±8·4 |

TABLE 7

PLASMA PROTEINS BEFORE AND AFTER EXPOSURE TO TNT (Cf. legend to Table 3)

| Investigation | Group I | | | Group II | | | Group III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference | Before exposure | After exposure | Individual percentage difference |
| Total plasma protein, gm. per 100 ml. .. .. | 7·0±0·05 | 6·7±0·05 | −4·3±0·8 | 7·4±0·55 | 6·9±0·15 | −6·7±1.4 | 7·3±0·16 | 6·7±0·08 | −8·2±1·4 |
| Plasma albumin, gm. per 100 ml. .. .. | 4·7±0·04 | 4·5±0·05 | −4·2±1·08 | 4·9±0·12 | 4·5± 0·11 | −8·1±2·5 | 4·9±0·08 | 4·5±0·05 | −8·1±1·76 |
| Plasma globulin, gm. per 100 ml. .. .. | 2·1±0·05 | 2·0±0·05 | −4·8±2·84 | 2·2±0·13 | 1·9±0·12 | −13·6±5·1 | 2·2±0·06 | 1·9±0·001 | −13·6±7·8 |
| Plasma fibrinogen, mgm. per 100 ml. .. | 276±8·1 | 266±8·1 | −3·6±2·8 | 308±28·1 | 226±16·0 | −21·6±9·7 | 251±10·3 | 253±8·5 | 0·8±5·4 |

Unfortunately five days had elapsed between his being taken off contact and his return to Oxford, nevertheless he still had 8 per cent. total non-oxygen carrying pigment in the blood and the " sulphaemoglobin " band (6210) was just visible in the spectrum.

PLASMA BILIRUBIN. Group I showed a slight but significant rise in the average level of the total serum bilirubin after exposure, i.e. 0·38–0·51 mg. per 100 c.c. Four individuals showed a rise varying from 0·5 to 1·9 mg. per 100 c.c. In Groups II and III the total bilirubin values after exposure were even higher, and the average final values were over 1·0 mg. per cent. If the figures from these two groups are analysed separately the individual variation is such that a significant difference cannot be established, but taking the two groups together the difference is significantly different from zero. This suggests that it is reasonable to suppose that there was a systematic rise in bilirubin in all the three groups.

In one man in Group II the total plasma bilirubin was 2·4 mg. per cent. before exposure and 3·8 per cent. after. The other tests of liver function were normal and he felt no subjective ill effects. His haemoglobin fell from 99 to 89 per cent.

The man in Group III who developed anilism had an initial total bilirubin value of 0·6 mg. per cent. and a final value of 5·0 mg. per cent. It is noteworthy that his maternal grandfather and uncle had both died of cirrhosis of the liver. The man himself was liable to fat dyspepsia but otherwise fit.

In about half the cases (24 females, 6 males) the

amount of bilirubin that gave the direct reaction was estimated separately. The results showed that the rise in total bilirubin was largely accounted for by the rise in the indirect bilirubin, there being little or no change in the value for the direct. For instance, in the case from Group III with a final value of 5·0 mg. total bilirubin, 4·2 mg. gave the indirect reaction. In view of the evidence of destruction of circulating red cells, the rise in the plasma bilirubin was more likely to be due to haemolysis than to a toxic effect on the liver, nevertheless the fact that the liver was unable to maintain a normal plasma level while excreting the increased amount of pigment suggests some impairment of function. (Watson, 1937.)

PLASMA PHOSPHATASE. HIPPURIC ACID EXCRETION. LAEVULOSE TOLERANCE. In these tests there was only a slight difference in the average values before and after exposure. In five cases there was a fall of more than 15 per cent. in the amount of hippuric acid excreted in four hours, and in four of the other cases a rise above 15 units in the plasma phosphatase. In no single case was the rise in laevulose index greater than the corresponding fall in other instances, suggesting that the changes observed did not fall outside the error of the method. No single individual showed a comparable change in more than one of the tests.

PLASMA PROTEINS. In all three groups a slight but definite fall in plasma proteins was observed which was greater in the men than in the women, and slightly larger in Group III than Group II. This happened in spite of the fact that the protein intake during the working period was estimated to be as high as 85–130 g. daily and the total caloric value of the diet at 2800–3800 calories.

VITAMIN A. Thirty-five subjects examined. Three had initial vitamin A levels below 60 I.U. per 100 ml. plasma. After exposure eight different subjects had similar low values. Six showed an increase of 20 I.U. and twelve a decrease of the same magnitude.

COCARBOXYLASE. Thirty-seven subjects examined. Ten had initial values of 2 mg. per 100 ml. blood. After exposure five, of whom four had initial low values, had similar amounts. Seven subjects showed an increase of 1 mg. per 100 ml. blood and two had a decrease of a similar amount.

VITAMIN C. Where possible, estimation of vitamin C in the white layer of spun blood (mg. vitamin C per 100 g. white layer) and plasma (mg. vitamin C per 100 ml. plasma) were made. Thirty-seven subjects were examined; twenty-six showed no change, five had an increase of more than 5·0 mg. per 100 g. white layer, or more than 0·5 mg. per 100 ml. plasma, and five had a similar decrease. One subject had a critically low value at the initial examination, but it became normal after exposure and no one had a critically low value after the working period.

It was an oversight that the erythrocyte sedimentation reaction was omitted, for there is evidence that this may be raised after exposure to TNT. (Noro, 1941.)

## Discussion

There were significant changes in the blood picture in over 80 per cent. of the students. The haemoglobin was depressed by 10–15 per cent. and there was a mild orthochromic anaemia with an increase in the level of reticulocytes, a tendency to icterus of the haemolytic type, the appearance of urobilin in the urine, and in the more severe examples, hyperplasia of the bone marrow. The anaemia was slight and might well be overlooked in a survey of factory workers, unless careful controls were taken. At the end of the experiment the haemoglobin levels in our students were still higher than those commonly observed in war-time England. The reticulocytosis also was not very great during the period of actual exposure but it became more evident when the worker left contact with TNT. Noro (1941) made an identical observation on the reticulocytes of TNT and tetryl workers in Finland during the Russo-Finnish war. These observations suggest that reticulocytosis is a reparative phenomenon which is to some extent inhibited by the TNT. Thus increase of haemolysis and depression of the haemoglobin values are accompanied by some degree of interference with haemopiesis. We are therefore justified in concluding that TNT has a haemolytic effect on the majority of those brought in contact with it. The effects are disguised to some extent by the successful response of the marrow, but no haemotologist could ignore the changes in the blood and the bone marrow after exposure to TNT.

These results may excite surprise, for opinion in this country has been much influenced by the work of Panton (1917). Panton examined 50 female TNT workers. The average values in 24 women who had been at the work more than three months were: red cells, 5,200,000 per c.mm.; haemoglobin, 88·7 per cent.; in 26 women who had been engaged less than three months: red cells, 5,700,000 per c.mm.; haemoglobin, 90 per cent. There seems to be no doubt that these women were in contact, for their urine gave a positive Webster reaction and some were cyanosed. Moreover, 20 per cent. of another 100 women examined at this factory had "cholaemia," of the serum, which was tinged with bile as judged by naked eye examination. On the other hand, Minot (1919) came to the conclusion that TNT resulted in increased destruction and increased formation of red blood cells. His experiment invited criticism because the tests were performed by medical students, and the results in only 223 of the 600 workers examined were published, no reason being given for the omission of the remainder. The haemoglobin was not estimated and Minot based his opinion on changes in the shape and size of the red cells. Minot's conclusions, therefore, failed to convince other workers in the field.

Nevertheless, subsequent work in man and animals has shown that Minot was right. This work has been ably reviewed by Noro (1941) and we need only repeat the bare facts here. Animal studies have been extended by Himsworth and Glynn (1942) who have demonstrated that chronic TNT poisoning in rats produces a fall in the haemoglobin content of the blood; an erythroblastic reaction of the bone-marrow associated with the appearance of normoblasts, reticulocytes and polychromatic cells, and also of polymorphonuclear cells in the peripheral blood; and an increased deposition of iron in the spleen. The changes in the blood cells, the marrow and the spleen are in general more pronounced in rats on a fat diet, but also occur to a lesser extent in animals on carbohydrate and protein diets. Voegtlin, Hooper and Johnson (1922) found anaemia in 72 per cent. of 237 workers in a TNT factory. It was characterized by a reduction in haemoglobin percentage, the presence of anisocytosis and poikilocytosis, polychromatophilia, fragmentation of red cells, and the appearance of nucleated and reticulated cells in the circulating blood. Noro (1941) found anaemia in 17 out of 38 workers in TNT and a similar incidence in workers in tetryl. He drew particular attention to the high colour index and the frequent occurrence of thrombocytopenia and increased rate of erythrocyte sedimentation. Davie (1942) found that the reticulocyte count in TNT workers was double the normal average.

The unexpected findings that the students working in the melt houses were more severely affected than those in the filling shops, raises the question of the routes of absorption of TNT. Benjamin Moore (1917) in the last war came to the conclusion that the only important route was the skin. In the melt houses the temperature at platform level is high and the TNT is present in the form of fume or vapour. If it is true that exposure under these conditions produces a more acute effect than in the filling shops, all that we are justified in concluding is that a high temperature favours the absorption of TNT. Few chapters of science are more convincing than Moore's demonstration of the preponderant rôle of the skin in the absorption of TNT. Nevertheless opinion is gaining ground that workers absorb TNT by the lungs and the alimentary tract and the changes in the blood and blood-forming organs in the young men in the melt houses were severe enough to suggest the need for further experiments to determine the mode of absorption of TNT there.

Evidence of liver damage in our series was slight and not wholly convincing. This suggests that TNT acts on the liver less rapidly or less constantly than on the blood, or else that our tests of liver function are not sensitive enough to be certain of early changes. Probably each of these factors has influenced the results, but more work is required before the point can be decided. Meanwhile, suggestive changes in the plasma phosphatase and hippuric acid test were observed in 17 per cent. of cases. It may also be argued that the failure to maintain a normal level of plasma bilirubin and a urine free of urobilin in the face of a relatively mild haemolytic anaemia was evidence of an impairment of hepatic function. (Watson, 1937.) The fall in plasma protein, though statistically significant, was small. In the absence of other causes it too may reflect a change in liver function (Weech, 1938). The absence of an increase in coproporphyrin excretion is rather surprising in view of the blood changes.

To return to the point of departure of this investigation, it would appear that the period of exposure was too short to follow to a conclusion the initial reactions to exposure to TNT. The average stay at the factory was a little less than five weeks, whereas the incidence of TNT jaundice rises to a peak at 15–16 weeks. It is therefore possible that the haemopietic reaction might have been modified and impairment of liver function and porphyrin metabolism might have been detected if the experiment had been continued longer. The haematological changes are presumably due to increased haemolysis and attempts at compensation by the bone-marrow. It is probable that after a time tolerance is acquired and haemopiesis returns to a normal level. These are possibilities which we hope to work out by a more continuous and prolonged study of a few individuals. In the early stages, at any rate, TNT exerts a deleterious effect on the blood in man. It inhibits the marrow as well as increasing the destruction of the circulating red cells. Only when the subject is removed from exposure is the marrow able to exert its full power of repair and produce a maximal reticulocyte response. It is therefore not surprising that a refractory or aplastic type of anaemia develops in isolated cases of exposure to TNT.

As regards the value of laboratory tests, the estimation of haemoglobin, red cells, reticulocytes and serum bilirubin gives useful information about the effects from TNT during the early period of exposure. Unfortunately reticulocytosis is not so conspicuous during exposure as it is after 48 hours or more off contact. Noro's work suggests that the sedimentation of the red cells is accelerated when TNT is absorbed. On the other hand, tests of liver function are too time-consuming and the results too uncertain to be of much value as routine procedures in the early weeks. There is no correlation between the Kennedy-Ingham reaction and the excretion of coproporphyrin, and the significance of the former reaction remains to be decided. On the other hand, the direct indican reaction in the urine is so frequently positive in TNT sickness that it might prove valuable as a confirmation of this diagnosis. Anaemia, reticulocytosis, bilirubinaemia and direct indicanuria are pathological phenomena and they provide criteria with more meaning than the Webster reaction and similar urinary tests, which merely signify the excretion of TNT or its derivatives.

## Summary

Sixty-two undergraduates were sent to a filling factory for periods varying from four to eleven weeks. During this time they obeyed the same rules and regulations as the regular operatives; received the same rates of pay; and were housed in one of the government hostels for factory workers. Most of the students remained in good health throughout the period of their work.

Immediately before and after exposure a series of tests were carried out in the Biochemical Laboratory of the Radcliffe Infirmary and the Oxford Nutrition Survey. The tests were designed to investigate the effects of TNT on the haemopoietic system, the liver and the general nutrition. These tests were of a detailed type in order to determine any possible early actions of TNT.

Four subjects who experienced abdominal pain were examined with a gastroscope. The gastric mucosa showed mild catarrhal effects.

In 85 per cent. of cases the level of haemoglobin and circulating red blood cells was reduced, indicating that, under the conditions of exposure, TNT acted as a haemolytic agent. The bone-marrow responded to this destruction by a heightened erythropoiesis and an increase in the number of reticulocytes in the circulation; the highest reticulocyte levels were attained after removal from contact.

A significant increase in the plasma bilirubin occurred in 20 per cent. of cases; the greater part was in the direct form.

There was no alteration in the laevulose tolerance test in the series as a whole but in four cases the plasma phosphatase was over fifteen units after exposure and in five the excretion of hippuric acid was reduced by 15 per cent or more.

There was a small but significant fall in the plasma proteins after exposure in over 70 per cent. of the students. A few subjects showed a fall in the vitamin A content of the blood, but there was no appreciable change in the cocarboxylase or vitamin C.

Haemolytic effects were more marked in the men than in the women, and were greatest in the group working in melt houses, where the room temperature and the concentration of TNT fumes was greater than in the filling shops.

The reticulocyte count, the erythrocyte sedimentation rate and the direct indican reaction in the urine are simple tests which merit further evaluation in the control of harmful exposure to TNT. During the first weeks on contact they appear to be of greater clinical significance than the Webster reaction, the Kennedy-Ingham reaction or the excretion of coproporphyrin.



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# DETERMINATION OF AIR-BORNE TRINITROTOLUENE, TETRYL AND DINITROTOLUENE

BY

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Since the commencement of the present war, a number of methods have been described for the estimation of airborne TNT (2 : 4 : 6 trinitrotoluene), by Kay (1941), Pinto and Fahy (1942), Goldman and Rushing (1943) and Cone (1943).

With a view to producing a simple and portable system which could be readily used by an inexperienced worker and might be expected to give accurate results, we have developed a method which, in a broad sense, is based on that of Kay. Kay's method is a colorimetric one dependent on the red colour developed by the action of caustic alkali on TNT in acetone solution. The air containing TNT is drawn through 150 c.c. of acetone: aliquot portions of this solution are treated with alkali and the quantity of TNT present estimated by the intensity of the red colour produced. The colour is stated to be unstable after about 30 minutes.

The main idea of our method has been to produce the colour in situ in a bubbling tube and compare directly with standards. For such a method, acetone is not suitable, partly because of its volatility and partly because of the instability of the colour produced with alkali.

After trial with a large variety of solvents of a less volatile nature, the most suitable was found to be cyclohexanone. This solvent is relatively non-volatile (b.p. 156° C.) and gives an intense red colour when dissolved TNT is treated with alkali. This red colour is very stable and can be kept for a week without fading. The only outstanding disadvantage is the sparing solubility of the alkali in cyclohexanone and it is necessary to shake the cyclohexanone and alkali solution together very thoroughly before apparent interaction between the TNT and alkali takes place. It is possible, however, to increase the mutual solubilities of the alkali and solvent by using a mixture of cyclohexanone and methylethylketone (b.p. 80° C.), the latter being less volatile than acetone and yet possessing miscibility with water. The colour produced in this solution is intense and permanent and conforms to Beer's Law and is therefore suitable for this estimation.

In an exactly similar way, a quantitative colour can be produced with tetryl (2 : 4 : 6 trinitrophenyl-1-methylnitramine); in this case, the colour is of a brownish-red and is not quite so stable as with TNT.

Channon, Mills and Williams (1944) have recently published a list of the colours produced by a number of nitro compounds when treated with this reagent.

With the collaboration of The Tintometer, Ltd., discs have been prepared for TNT and tetryl, affording a range of nine permanent standards for each compound. A description of the method for estimation of TNT and tetryl follows. This method has been employed with success over a period of two years.

## A. Method for TNT and Tetryl

### Apparatus

The accompanying photographs (Figs. 1 and 2) show the apparatus employed.

FIG. 1.—Assembled pump equipment, Tintometer, disc and cell.

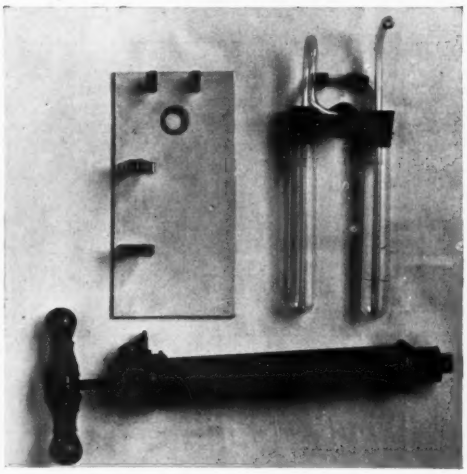

FIG. 2.—Dismantled pump equipment.

(*a*) *Pump.* This is the standard pump designed by the Department of Scientific and Industrial Research for the estimation of toxic gases in industry. The capacity of this pump is 125 ml. per stroke. It is fitted with a stroke counter.

(*b*) *Tube Mounting.* On the inlet of the pump is mounted a thin board painted white, 8 in. by 4 in., which carries the trap, sampling tube and air inlet. This is easily dismantled for transport as all the tubing is fixed by spring clips.

This board is screwed between the main inlet valve-holder of the pump and the adaptor. The tubing for connection to the bubbler system is fitted to the adaptor. It is essential to have washers on either side of the board to give a gas-tight joint.

(*c*) *Tubing.* All tubing connections are made of glass, and the bubbler tubes are of 0·75 in. internal diameter by 6 in. long, having a graduation mark at 10 ml.

The air inlet tube has an overall length of 10 in. drawn out to a jet which just allows a wire of 24 S.W.G. to pass. Its upper end is curved with a radius of 1½ in. and terminates at 90 degrees to the tube. This design is to minimize the amount of dust deposited in the tube.

(*d*) *Tintometer.* The instrument is the All-purposes Lovibond Comparator. The cells are of 13·5 mm. internal width, having plane faces, and side walls of frosted glass.

### Standard Colours

The standard colours have been carefully chosen to cover a useful working range. On the Tintometer disc these colours are numbered 1 to 9 and correspond to the concentrations of TNT and tetryl recorded in Table 1 when using a cell of 13·5 mm. thickness.

Tables 2 and 3 correlate the number of strokes on the D.S.I.R. pump with the standard colour produced and give the results in milligrams of TNT or tetryl per cubic metre of air.

TABLE 1

| Standard numbers on discs | Concentration in mg./litre solvent (for cell 13·5 mm. thick) | |
|---|---|---|
| | TNT | Tetryl |
| 1 | 1·575 | 3·15 |
| 2 | 2·36 | 4·72 |
| 3 | 3·15 | 6·30 |
| 4 | 4·73 | 9·46 |
| 5 | 6·30 | 12·6 |
| 6 | 7·87 | 15·75 |
| 7 | 9·45 | 18·9 |
| 8 | 11·0 | 22·0 |
| 9 | 12·6 | 25·2 |

*N.B.* The above table holds for solutions of TNT in acetone (Kay method) provided comparison is made with the standards immediately after the colour is produced; otherwise, fading of the colour interferes with the estimation.

TABLE 2

MILLIGRAMS TNT/CUBIC METRE FOR SOLUTION THICKNESS, 13·5 MM. AND PUMP CAPACITY 125 ML.

| Number of strokes | Colour standard | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 13·0 | 19·0 | 25·0 | 38 0 | 50 0 | 63·0 | 75·0 | 88·0 | 100 |
| 15 | 9·0 | 14·0 | 19·0 | 28·0 | 38·0 | 47·0 | 56·0 | 66·0 | 75 |
| 20 | 6·0 | 9·0 | 13·0 | 19·0 | 25·0 | 31·0 | 38·0 | 44·0 | 50 |
| 30 | 5·0 | 7·0 | 9·0 | 14·0 | 19·0 | 23·0 | 28·0 | 33·0 | 38 |
| 40 | 3·0 | 5·0 | 6·0 | 9·0 | 12·0 | 16·0 | 19·0 | 22·0 | 25 |
| 50 | 2·5 | 4·0 | 5·0 | 7·5 | 10·0 | 13·0 | 15·0 | 18·0 | 20 |
| 60 | 2·1 | 3·2 | 4·2 | 6·3 | 8·4 | 10·7 | 13·0 | 15·0 | 17 |
| 75 | 1·9 | 2·8 | 3·8 | 5·7 | 7·6 | 9·3 | 11·0 | 13·0 | 15 |
| 100 | 1·25 | 1·9 | 2·5 | 3·75 | 5·0 | 6·25 | 7·5 | 8·75 | 10 |
| 125 | 1·0 | 1·5 | 2·0 | 3·0 | 4·0 | 5·0 | 6·0 | 7·0 | 8 |

These tables hold only so long as the pump capacity is 125 ml., but as the concentration of TNT and tetryl for each coloured standard is given in Table 1 in milligrams of TNT or tetryl per litre of solution, the figures giving airborne concentrations can be recalculated to suit a pump of a different capacity.

### Solutions

(*a*) *Solvent.* The solvents used must be of high purity. They are redistilled using an eight-bulb fractionation column.

(1) Cyclohexanone—fraction b.p. 154–156° C. is retained.

(2) Methyl ethyl ketone—fraction b.p. 79°–80° C. is retained.

TABLE 3

MILLIGRAMS TETRYL/CUBIC METRE FOR SOLUTION THICKNESS, 13·5 MM. AND PUMP CAPACITY 125 ML.

| Number of strokes | Colour standard | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 26·0 | 38·0 | 50·0 | 76·0 | 100·0 | 125·0 | 150 | 175·0 | 200 |
| 15 | 18·0 | 28·0 | 38·0 | 56·0 | 76·0 | 94·0 | 112 | 132·0 | 150 |
| 20 | 12·0 | 18·0 | 26·0 | 38·0 | 50·0 | 62·0 | 76 | 88·0 | 100 |
| 30 | 10·0 | 14·0 | 18·0 | 28·0 | 38·0 | 46·0 | 56 | 66·0 | 76 |
| 40 | 6·0 | 10·0 | 12·0 | 18·0 | 24·0 | 32·0 | 38 | 44·0 | 50 |
| 50 | 5·0 | 8·0 | 10·0 | 15·0 | 20·0 | 26·0 | 30 | 36·0 | 40 |
| 60 | 4·2 | 6·4 | 8·4 | 12·6 | 16·8 | 21·5 | 26 | 30.0 | 34 |
| 75 | 3·8 | 5·6 | 7·6 | 11·4 | 15·2 | 18·5 | 22 | 26·0 | 30 |
| 100 | 2·5 | 3·8 | 5·0 | 7·5 | 10·0 | 12·5 | 15 | 17·5 | 20 |
| 125 | 2·0 | 3·0 | 4·0 | 6·0 | 8·0 | 10·0 | 12 | 14·0 | 16 |
| 150 | 1·6 | 2·4 | 3·2 | 4·8 | 6·4 | 8·2 | 10 | 11·0 | 12 |
| 200 | 1·3 | 2·0 | 2·6 | 4·0 | 5·2 | 6·6 | 8 | 9·0 | 10 |
| 250 | 1·0 | 1·5 | 2·0 | 3·0 | 4·0 | 5·0 | 6 | 7·0 | 8 |

Equal volumes of the solvents are mixed and stored in a dark bottle. This mixed solvent should be a water-clear liquid.

(*b*) *Alkali.* Twelve grams of pure potassium hydroxide are dissolved in distilled water and made up to 100 c.c. This is kept in a bottle fitted with a dropping pipette, this being graduated to deliver 0·5 c.c. of alkali solution.

### Procedure

To a sampling tube solvent is added up to the 10 ml. graduation mark. This is followed by 0·5 c.c. of the KOH solution. The tube is shaken vigorously for 2 minutes so as to distribute thoroughly the alkali in the solvent and is then attached to the pump, which is operated at about 1 stroke in 5 seconds.

Bubbling is commenced in the atmosphere to be sampled and is continued until a distinct colour develops. The tube is removed and shaken again for 1 minute, suspended alkali is allowed to settle out for another minute and the contents of the tube then poured into a Tintometer cell 13·5 mm. wide and the colour matched off in the Tintometer against the standard disc.

From the number of strokes taken and the colour standard obtained on the appropriate disc, a direct reading of the concentration of the airborne material, TNT or tetryl, can be obtained from Tables 2 or 3.

### Note on Tetryl Estimation

As the tetryl colour tends to fade, the test must be carried out without delay and, when the number of strokes to give a colour is large (of the order of 100), it is advantageous to use the solvent alone and then to add alkali after bubbling and compare colour produced.

## B. Method for DNT (2 : 4 Dinitrotoluene)

The above method for TNT and tetryl is not applicable to the estimation of DNT. The method adopted for DNT is based on the absorption of the DNT by a naphthalene filter (Briscoe, 1939), followed by the solution of the naphthalene in a mixed solvent of acetone and cyclohexanone with subsequent addition of alkali and the formation of a blue colour due to 2 : 4 DNT. Pure 2 : 6 DNT which usually occurs in association with 2 : 4 DNT in the dinitration product of mononitrotoluene to about 20 per cent. gives no colour with alkali. The blue colour which is produced with 2 : 4 DNT develops slowly and is unstable. It was not found possible to stabilize or accelerate the colour change.

With acetone a royal blue colour is produced, with cyclohexanone a violet blue, and with methyl ethyl ketone a violet colour, the latter developing only very slowly.

It was decided to use a mixture of 90 per cent. acetone with 10 per cent. cyclohexanone as this gave a blue colour which reached a suitable maximum shade after 10 minutes. This colour was satisfactorily matched against aqueous solutions of Gentian violet as standards.

**Solutions**

(*a*) *Solvent.* The solvent used throughout is a mixture of 10 per cent. cyclohexanone and 90 per cent. acetone by volume.

The cyclohexanone is purified by distillation, b.p. 154°–156° C.: acetone, b.p. 56° C.

(*b*) *Alkali.* Twelve grams of pure potassium hydroxide is dissolved in distilled water and made up to 100 c.c.

**Naphthalene**

This must be pure and should give no colour with alkali when dissolved in acetone. It may be necessary to sublime the naphthalene in order to obtain a pure product, m.p.=80° C. This is now finely ground and placed in a stoppered bottle.

**Standard Colours**

Four solutions of 2 : 4 DNT in the solvent are made up so as to contain respectively (i) 0·03125, (ii) 0·0625, (iii) 0·09325, and (iv) 0·125 milligrams of DNT per 100 c.c., diluting appropriately to obtain the solutions above.

To 10 c.c. of each of these is added 0·5 c.c. of the KOH solution and the tubes shaken thoroughly. On the expiry of 10 minutes after the addition of the alkali, the blue colours produced are matched by aqueous solutions of Gentian violet. These latter standards are numbered 1 to 4 and are retained in well corked tubes 6 in. long by 0·75 in. internal diameter. They are stable for several weeks but should be rematched from time to time.

**Apparatus**

The standard D.S.I.R. pump is used, but instead of carrying the tubing and bubblers, a small No. 1 sintered glass micro filter 12 mm. diameter and about 30 mm. long is attached by insertion in a rubber stopper fitted into the nozzle of the pump. A filter pad of naphthalene is made by using 0·4–0·5 gm. of the ground material. The naphthalene is firmly pressed down on to a disc of filter paper resting on the sintered surface. The naphthalene filter is prepared in this way before entering the atmosphere to be tested.

**Procedure**

The contaminated atmosphere is drawn through the filter by means of the hand pump at about the rate of 1 stroke in 5 seconds. If concentrations are known to be high, 30–50 strokes are taken, but if concentrations are low, 100 or even 150 strokes may be necessary. After the sample has been taken the naphthalene filter is carefully loosened from the sinter with a spatula and is dropped into a test-tube (6 in. by 0·75 in.). It will be found that the naphthalene comes away almost completely from the micro filter and the small crystals remaining can be carefully scraped into the test-tube; 10 c.c. of the solvent are now added and the tube shaken to assist the solution of all the naphthalene. To this is now added 0·5 c.c. of 10 per cent. KOH and the tube shaken again. The time of the addition of the alkali is noted and, 10 minutes after this, the colour which develops is matched against the standards.

From the table which follows, an estimation of the concentration can readily be made. This table holds only provided the pump is of 125 ml. capacity.

As this method only takes account of the 2 : 4 DNT present, it is desirable in most cases to add 25 per cent. to the figure obtained to give total DNT.

TABLE 4

MILLIGRAMS DNT/CUBIC METRE FOR PUMP CAPACITY 125 ML.

| Number of strokes | Colour standard | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 30 | 8·0 | 17·0 | 25·0 | 33 |
| 50 | 5·0 | 10·0 | 15·0 | 20 |
| 100 | 2·5 | 5·0 | 7·5 | 10 |
| 150 | 1·7 | 3·4 | 5·0 | 7 |

**Summary**

Airborne TNT and tetryl are estimated colorimetrically in situ by absorption of the material in a mixed solvent of methyl ethyl ketone and cyclohexanone to which a little potassium hydroxide solution has been added. Rapid assessment of the results is obtained by using a comparator and a special Tintometer disc.

Airborne DNT is absorbed in a naphthalene filter which is then dissolved in acetone and cyclohexanone containing potassium hydroxide. The colour produced is matched against aqueous standards containing Gentian violet.

**Acknowledgment**

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# STUDY OF ABSENCE FROM WORK AMONG WOMEN IN A WAR FACTORY

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### Nature and Scope of the Inquiry

The investigation here described is an extension of an earlier statistical study of sickness absence among women in industry.* Both had much in common but the later study, unlike the earlier, included all the women in a factory and was concerned with absence due to leave and without permission as well as with sickness absence. The factory chosen was engaged in the manufacture of fuzes, and the absence records relate to all the women on the books during the last six months of 1943. These consisted of 2926 women who were employed throughout the period, 332 who left, and 43 who began work during the period. The procedure adopted was to copy, from the factory records, the length and nature of each absence and to relate this information to factors such as civil state, age and length of service. The total number of days in the period from July 1 to December 31 was 184. The non-working days deducted from this total were: 26 Sundays, 6 days annual holiday, 2 days in September instead of August Bank holiday week-end, and 2 days at Christmas. Hence the total number of possible working days for each woman employed for the whole period was 148.

Whilst space precludes giving the *actual* number of days lost from (*a*) sickness, (*b*) leave, and (*c*) absence without permission, the figures in Table 1 show the possible working days on which the *percentage* figures given later are based, and from these readers who desire to do so can calculate the actual days lost. All differences referred to have been tested for statistical significance unless otherwise stated.

TABLE 1

NUMBER OF POSSIBLE WORKING DAYS FOR WOMEN WHO REMAINED EMPLOYED (E) LEFT (L) AND BEGAN WORK (B) DURING THE PERIOD, AND DISTINGUISHING MARRIED AND SINGLE WOMEN

| Married women | A—In age groups 15–24 | 25–34 | 35–44 | 45+ | Total |
|---|---|---|---|---|---|
| E | 52,836 | 79,920 | 47,508 | 7,548 | 187,812 |
| L | 6,276 | 7,044 | 3,012 | 1,572 | 17,904 |
| B | — | — | — | — | 1,260 |
| | | | | | 206,976 |
| **Single women** | **15–24** | **25–34** | **35+** | | **Total** |
| E | 168,276 | 51,948 | 25,012 | | 245,236 |
| L | 2,964 | 1,308 | 960 | | 5,232 |
| B | — | — | — | | 984 |
| | | | | | 251,452 |

| Married women | B—By years of service 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | Total |
|---|---|---|---|---|---|---|
| E | 10,804 | 35,076 | 81,992 | 54,168 | 5,772 | 187,812 |
| L | 1,704 | 4,284 | 7,320 | 4,224 | 372 | 17,904 |
| | | | | | | 205,716 |
| **Single women** | | | | | | |
| E | 19,536 | 51,948 | 97,384 | 61,124 | 15,244 | 245,236 |
| L | 240 | 1,524 | 2,400 | 936 | 132 | 5,232 |
| | | | | | | 250,468 |

### Results obtained

(*a*) *Amount of Absence*

The average number of working days lost by married and single women in the last six months of 1943 through (*a*) sickness,† (*b*) leave, and (*c*) absence without permission has been expressed as a percentage of the total number of working days in the period and the figures so obtained are given in Table 2.‡ In the case of women who left or began work during the period, the percentage time lost was reckoned up to the date of leaving or from the date of entry.

Thus the time lost due to all causes was 24·9 per cent. for married women and 11·3 per cent. for single women, or an average loss of 17·5 per cent. The latter figure agrees fairly closely with the average loss of 16·8 per cent. for the same period in 52 factories employing a total of 168,762 women.

Approximately two-thirds of the total time lost was due to sickness absence and only a small proportion to absence without permission.

TABLE 2

PERCENTAGE OF WORKING DAYS LOST THROUGH SICKNESS, LEAVE AND ABSENCE WITHOUT PERMISSION BY WOMEN WHO REMAINED IN EMPLOYMENT (E), LEFT (L) AND BEGAN WORK (B) DURING THE PERIOD

| | Married | | | | Single | | | |
|---|---|---|---|---|---|---|---|---|
| | E | L | B | All workers | E | L | B | All workers |
| Sickness | 14·5 | 29·6 | 9·4 | 15·8 | 7·5 | 27·8 | 11·7 | 7·9 |
| Leave | 5·5 | 8·4 | 4·1 | 5·7 | 1·5 | 4·3 | 3·3 | 1·5 |
| Without permission | 2·7 | 10·9 | 6·6 | 3·4 | 1·9 | 2·9 | 3·9 | 1·9 |
| All causes | 22·7 | 48·9 | 20·1 | 24·9 | 10·9 | 35·0 | 18·9 | 11·3 |
| Number of workers | 1,269 | 254 | 23 | 1,546 | 1,657 | 78 | 20 | 1,755 |
| Per cent. of total | 82·1 | 16·4 | 1·5 | 100·0 | 94·4 | 4·4 | 1·1 | 99·9 |

* I.H.R.B. Rep. No. 86 (1944). H.M.S.O. Lond.
† Including accidents inside and outside the factory. These accounted for a total loss of only 0·4 per cent.
‡ Sickness absence refers to certified sickness absence of two or more days.
Leave refers to absence with permission due mainly to husbands on leave or home duties.
Absence without permission, or casual absence, refers to occasional days lost without reasonable excuse.

Of those who left during the period, a large majority were discharged because of ill-health or domestic difficulties, hence it is not surprising that their rate of absence before leaving was very high. It will be noted that the rate of discharge was much higher for married women than for single women; thus the former not only lost more than twice as much time as the latter but also had a much higher rate of discharge.

No significance can be attached to the absence rate of those who began work during the period because of the small number of women in this category. The inclusion of these women merely completes the picture of absence from work and their figures have no effect on the general trends.

Further analysis of the data from the main group (E) showed that the proportion of married women who were absent for more than half the period was 5·3 per cent. and of single women 1·5 per cent. and they accounted for 16·5 per cent. and 10·0 per cent. respectively of the total time lost by these two groups. Hence comparatively few women were responsible for a fairly large proportion of the total time lost.

(*b*) *Absence in relation to Age*

The amount of absence recorded for married and single women in different age groups is shown in Table 3.*

Before considering the amount of absence, it may be noted that 68·2 per cent. of the single women were under 25 and only 10·5 per cent. over 35; the corresponding figures for married women were 29·0 and 28·6 per cent. respectively.

There was a difference between the age distributions of married women in the E and L groups, the proportion of leavers over 35 being relatively high. Since there was no significant difference between the corresponding groups of single women, it follows that the age distribution of leavers was related to civil state.

There was also a difference in the age distributions of married and single women in the E groups owing to the predominance of single women under 25, hence the age distribution of all married and single women was different.

As regards sickness absence, the figures of both married and single women tended, with the exception of one age group, to increase as age increased. The exception was the relatively high rate of absence of married women under 25 which was most noticeable in the main group (E). A similar tendency was also noticeable in the group of single women who left during the period.

Absence due to leave was, for married women, also most marked in the lowest age group but, unlike sickness absence, it continued to decrease as age increased. The corresponding figures for single women showed no significant difference.

Absence without permission tended, if anything, to decrease as age increased, the only exception worth noting being the rise in the small group of married women over 45 who left before the end of the period.

Although the figures in Table 3 show that the age of workers must be taken into account when considering absence from work, of more importance is the demonstration that, age for age, married women lost more time than single women. In other words, the higher rate of absence of married women (Table 2) was not due to their higher average age but must be attributed to the effects of the additional duties and difficulties of married life. It is also significant that the difference between the amount of absence of married and single women decreased as age increased. The ratios for different age groups were:

| | Ratio | |
|---|---|---|
| Age group | Married | Single |
| 15–24 | 2·49 | 1·00 |
| 25–34 | 2·06 | 1·00 |
| 35+ | 1·85 | 1·00 |

These figures suggest that the additional strains of married life decreased with increasing age though it is also possible that the worries and difficulties of some single women increased with age.

The figures in Table 3 also show that the rate of discharge of married and single women varied in the different age groups. The percentage rate† for each age group was:

| Married | | Single | |
|---|---|---|---|
| Age group | Percentage rate | Age group | Percentage rate |
| 15–24 | 19·0 | 15–24 | 3·9 |
| 25–34 | 16·1 | 25–34 | 4·6 |
| 35–44 | 11·7 | 35+ | 7·5 |
| 45+ | 26·2 | | |

Thus the rate of discharge of married women decreased up to the age group 35–44 and then increased, while that of single women continued to increase in each higher age group. There was no apparent reason, apart from the effects of married life, why the rate of discharge of

TABLE 3

PERCENTAGE OF WORKING DAYS LOST THROUGH SICKNESS, LEAVE AND ABSENCE WITHOUT PERMISSION BY WOMEN IN DIFFERENT AGE GROUPS WHO REMAINED IN EMPLOYMENT (E) AND LEFT (L) DURING THE PERIOD

| | | Married women Age group | | | | | Single women Age group | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Group | 15–24 | 25–34 | 35–44 | 45+ | All ages | 15–24 | 25–34 | 35+ | All ages |
| Sickness | E | 15·4 | 13·9 | 14·5 | 15·1 | 14·5 | 7·2 | 8·1 | 8·5 | 7·5 |
| | L | 29·8 | 28·8 | 29·1 | 33·3 | 29·6 | 27·0 | 21·1 | 39·5 | 27·8 |
| | Both | 16·9 | 15·1 | 15·4 | 18·3 | 15·8 | 7·5 | 8·4 | 9·6 | 7·9 |
| Leave | E | 6·1 | 5·7 | 5·0 | 2·0 | 5·5 | 1·3 | 1·7 | 1·8 | 1·5 |
| | L | 9·8 | 8·6 | 6·2 | 6·4 | 8·4 | 5·2 | 1·8 | 4·6 | 4·3 |
| | Both | 6·5 | 5·9 | 5·0 | 2·8 | 5·7 | 1·4 | 1·7 | 1·9 | 1·5 |
| Without permission | E | 2·9 | 2·7 | 2·5 | 1·9 | 2·7 | 2·0 | 1·8 | 1·3 | 1·9 |
| | L | 10·0 | 11·4 | 7·1 | 19·3 | 10·9 | 2·8 | 3·5 | 2·2 | 2·9 |
| | Both | 3·7 | 3·4 | 2·8 | 4·9 | 3·4 | 2·0 | 1·8 | 1·3 | 1·9 |
| All causes | E | 24·4 | 22·3 | 22·0 | 19·0 | 22·7 | 10·5 | 11·6 | 11·6 | 10·9 |
| | L | 49·6 | 48·8 | 42·4 | 59·0 | 48·9 | 35·0 | 26·4 | 46·3 | 35·0 |
| | Both | 27·1 | 24·4 | 23·2 | 26·0 | 24·9 | 10·9 | 11·9 | 12·8 | 11·3 |
| Number of workers | E | 357 | 540 | 321 | 51 | 1,269 | 1,137 | 351 | 169 | 1,657 |
| | L | 85 | 105 | 43 | 21 | 254 | 47 | 17 | 14 | 78 |
| | Both | 442 | 645 | 364 | 72 | 1,523 | 1,184 | 368 | 183 | 1,735 |
| Per cent. of total | | 29·0 | 42·4 | 23·9 | 4·7 | 100·0 | 68·2 | 21·2 | 10·5 | 99·9 |

* The few women who began work during the period (23 married women and 20 single women) have not been included as their absence records had no significance.

† Based on the total number on the books during the period, i.e. including the few women who began work during the period.

young married women should be so much higher than that of single women of the same age, and the figures thus emphasize still more the burdens of younger married women. At the same time there is reason to believe that some of the younger women resented continued employment in the factory, either because of personal reasons or because they were 'directed,' and took advantage of every possible excuse to leave. It is probable, for instance, that some young women decided to start a family so as to obtain release from factory work.

It may be noted that the exclusion of absences due to pregnancy from the figures of sickness absence in Table 3 tended, if anything, to accentuate the relation between sickness absence and age, viz.:

| | Age groups (married women) | | | |
|---|---|---|---|---|
| Group | 15–24 | 25–34 | 35–44 | 45+ |
| E .. .. | 13·2 | 11·4 | 14·2 | 15·2 |
| L .. .. | 23·2 | 22·1 | 27·6 | 33·3 |
| Both .. .. | 14·2 | 12·3 | 15·0 | 18·3 |

Finally, it should be mentioned that the relation between absence and age as shown in Table 3 was not affected by length of service since there were no important differences in the length of service distributions of women in the different age groups.

*(c) Absence in relation to Length of Service*

A classification of absence according to length of service is given in Table 4.* The length of service was reckoned up to the end of June, 1943.

TABLE 4

PERCENTAGE OF WORKING DAYS LOST THROUGH SICKNESS, LEAVE AND ABSENCE WITHOUT PERMISSION BY WOMEN OF DIFFERENT LENGTHS OF SERVICE WHO REMAINED IN EMPLOYMENT (E) AND LEFT (L) DURING THE PERIOD

| | | Married women: Years of service | | | | | |
|---|---|---|---|---|---|---|---|
| | Group | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | Workers |
| Sickness | E | 15·5 | 16·3 | 13·5 | 15·0 | 12·0 | 14·5 |
| | L | 28·4 | 25·4 | 32·9 | 27·9 | 38·5 | 29·6 |
| | Both | 17·3 | 17·3 | 15·0 | 16·0 | 13·6 | 15·8 |
| Leave .. | E | 6·2 | 5·0 | 5·8 | 5·2 | 5·4 | 5·5 |
| | L | 14·7 | 8·6 | 6·9 | 9·1 | 1·1 | 8·4 |
| | Both | 7·4 | 5·4 | 5·9 | 5·5 | 5·1 | 5·7 |
| Without permission | E | 3·5 | 2·6 | 2·7 | 2·5 | 3·1 | 2·7 |
| | L | 25·5 | 12·3 | 7·5 | 8·4 | 23·4 | 10·9 |
| | Both | 6·5 | 3·6 | 3·1 | 2·9 | 4·4 | 3·4 |
| All causes | E | 25·2 | 23·9 | 22·0 | 22·7 | 20·5 | 22·7 |
| | L | 68·6 | 46·3 | 47·3 | 45·4 | 63·0 | 48·9 |
| | Both | 31·2 | 26·3 | 24·0 | 24·4 | 23·1 | 24·9 |
| Number of workers | E | 73 | 237 | 554 | 366 | 39 | 1,269 |
| | L | 28 | 65 | 96 | 58 | 7 | 254 |
| | Both | 101 | 302 | 650 | 424 | 46 | 1,523 |
| Per cent. of total | | 6·6 | 19·8 | 42·7 | 27·8 | 3·0 | 99·9 |

| | | Single women | | | | | |
|---|---|---|---|---|---|---|---|
| Sickness | E | 7·9 | 8·3 | 7·0 | 7·9 | 5·6 | 7·5 |
| | L | 16·7 | 26·2 | 30·2 | 30·8 | 2·3 | 27·8 |
| | Both | 8·0 | 8·8 | 7·6 | 8·3 | 5·6 | 7·9 |
| Leave | E | 1·1 | 1·7 | 1·4 | 1·7 | 0·9 | 1·5 |
| | L | 0·8 | 6·7 | 1·6 | 8·4 | 1·5 | 4·3 |
| | Both | 1·1 | 1·9 | 1·4 | 1·8 | 0·9 | 1·5 |
| Without permission | E | 1·7 | 1·9 | 1·9 | 2·0 | 2·0 | 1·9 |
| | L | 4·0 | 1·9 | 3·7 | 1·5 | 6·8 | 2·9 |
| | Both | 1·7 | 1·9 | 1·9 | 2·0 | 2·1 | 1·9 |
| All causes | E | 10·7 | 11·9 | 10·3 | 11·6 | 8·5 | 10·9 |
| | L | 21·5 | 34·8 | 35·5 | 40·7 | 10·6 | 35·0 |
| | Both | 10·8 | 12·6 | 10·9 | 12·1 | 8·6 | 11·3 |
| Number of workers | E | 132 | 351 | 658 | 413 | 103 | 1,657 |
| | L | 4 | 27 | 32 | 12 | 3 | 78 |
| | Both | 136 | 378 | 690 | 425 | 106 | 1,735 |
| Per cent. of total | | 7·8 | 21·8 | 39·8 | 24·5 | 6·1 | 100·0 |

* As in Table 3, the few women who began work during the period have been excluded.

Thus approximately 70·0 per cent. of the women had less than three years of service and very few had been employed for more than four years.

As regards absence from work, there was no consistent relation between the amount of time lost and length of service. Married women with less than two years of service tended to lose more time than those employed for longer periods, but the trend for single women was irregular.

Women with more than three years of service entered the factory at a time when it was possible to choose the fittest from a plentiful supply of labour. According to the management, they were 'handpicked' from the standpoint of health, appearance and suitability for work. Those with two to three years of service were also chosen with care but the standard was rather lower because of the more restricted choice. The shorter service workers were engaged when the demand for labour was almost equal to the supply and there was practically no choice. This progressive lowering of the standard would, other things being equal, tend to cause an increase in absence as length of service decreased. A similar effect would be produced by the weeding out of those most prone to absence, since the labour wastage due to this cause might be expected to decrease in each successive year of employment. This view is supported by the following figures which show the percentage discharged in each length of service group during the last six months of 1943.

| | Married women | | Single women | |
|---|---|---|---|---|
| Years of service | Number discharged | Percentage discharged | Number discharged | Percentage discharged |
| 0–1 | 28 | 27·7 | 4 | 2·9 |
| 1–2 | 65 | 21·5 | 27 | 7·1 |
| 2–3 | 96 | 14·8 | 32 | 4·6 |
| 3–4 | 58 | 13·7 | 12 | 2·8 |
| 4–5 | 7 | 15·2 | 3 | 2·8 |

The preceding considerations would probably account for the comparatively good records of those who entered the factory before the outbreak of war.

*(d) Sickness Absence*

The figures in Table 2 show that approximately two-thirds of the total time lost was due to sickness absence, hence a more detailed analysis of this source of loss is desirable. The procedure adopted for this purpose follows the lines recommended by a recent report on the recording of sickness absence in industry,† and the results are given in Table 5. They refer to women who remained in employment throughout the period (group E) and to those who left during the period (group L).

TABLE 5

SICKNESS ABSENCE CLASSIFIED ACCORDING TO DISEASE GROUPS

(Average number of days lost in each group expressed as a percentage of the number of working days possible)

| | Group E | | Group L | |
|---|---|---|---|---|
| Disease group | Married | Single | Married | Single |
| I. Colds and influenza .. | 2·99 | 1·91 | 2·62 | 1·97 |
| II. Respiratory system .. | 1·08 | 0·54 | 1·19 | 1·97 |
| III. Digestive system .. | 1·64 | 1·36 | 5·07 | 2·96 |
| IV. Rheumatism group .. | 0·93 | 0·27 | 0·93 | 1·80 |
| V. Functional nervous disorders .. | 0·35 | 0·18 | 1·91 | 2·66 |
| VI. Accidents at place of work | 0·22 | 0·21 | 0·04 | 1·01 |
| VII. Unclassified conditions .. | 7·31 | 3·05 | 17·85 | 15·43 |
| All groups .. | 14·52 | 7·52 | 29·61 | 27·80 |

† I.H.R.B. Rep. No. 85 (1944). H.M.S.O. Lond.

Considering first the main group (E), the figures show that colds and influenza were the most important single cause of sickness absence. The figures in question were, however, inflated by the effects of a mild influenza epidemic towards the end of 1943 and were almost three times as large as those for the corresponding period in 1942. Diseases of the digestive system were also responsible for much sickness absence and, among married women, the respiratory and rheumatism groups were prominent. It will be noted that functional nervous disorders occupied a relatively low position in the list of causes.

In the group of leavers (L), the figures show that married women had less absence through colds and influenza but more absence through digestive ailments and functional nervous disorders than those in the main group (E). Single women who left had more absence due to digestive ailments, rheumatism and functional nervous disorders. Both married and single women had more absence through unclassified causes.

Since the unclassified diseases accounted for approximately one-half of the total time lost through sickness, a further analysis was made with the following results:

| | Group E | | Group L | |
|---|---|---|---|---|
| Disease group | Married | Single | Married | Single |
| Circulatory .. .. | 1·52 | 0·61 | 2·79 | 3·69 |
| General debility, etc. | 1·22 | 0·82 | 2·89 | 2·26 |
| Genito-urinary .. | 0·86 | 0·12 | 2·02 | 0·00 |
| Pregnancy .. .. | 1·77 | 0·05 | 3·94 | 0·00 |
| Others .. .. | 1·94 | 1·45 | 6·21 | 9·48 |
| All sub-groups .. | 7·31 | 3·05 | 17·85 | 15·43 |

This classification shows that diseases of the circulatory system and ailments diagnosed as general debility, asthenia or general fatigue were also important causes of sickness absence. Among married women, the time lost through pregnancy and its complications was relatively high.

The figures in general indicate the types of sickness absence amongst those who left during the period. In a large majority of cases these absences were the main causes of their dismissal. Approximately 90 per cent. of the sickness absence of married leavers and 80 per cent. of single leavers were incurred by women who were discharged wholly or partly on grounds of ill-health. The remainder were usually discharged or allowed to leave because of domestic difficulties or removal to another district.

The relation between age and sickness absence in the main disease groups is shown in Table 6.

The figures show that the relation between sickness absence and age varied in the different disease groups. In some groups, the time lost increased with age but in others the opposite tendency was noticeable. In the main group (E) the figures show that the increase in sickness absence among married women under 25 (Table 3) was due mainly to colds and influenza, diseases of the circulatory system and general debility. Absences due to digestive ailments and pregnancy were also very prominent in this age group but they were also equally noticeable in the next age group (25–34). On the other hand, the absence rate for the circulatory and respiratory groups was highest among those over 45.

The figures for single women in the colds and influenza and rheumatism groups tended to increase with age and in this respect they were similar to the general trend of sickness absence as a whole (Table 3). They tended to decrease with age in the circulatory group but in the remainder the trends were irregular.

The figures for those who left during the period (group L) show that the relation between age and absence in the various disease groups was often substantially different from the relation in the main group (E). The married women who left, as compared with those who remained in employment, had in several disease groups a higher rate of absence in the lower and higher age groups. These increases were particularly noticeable in the colds and influenza group (over 35); the respiratory group (under 25); the digestive group (under 35); the rheumatism group (over 45); the circulatory and general debility groups (25–45), and pregnancy (under 25). The figures for single women who left are less reliable because of the smaller number of women in each age group. The most noticeable differences between these women and those in the main group (E) were a relatively higher rate of absence among the older women (over 35) in the colds and influenza, digestive, rheumatism and circulatory groups and a lower rate in the respiratory and general debility groups.

The figures in general give some indication of the relative importance of the diseases which preceded discharge from work and the age groups in which these diseases were most prevalent.

An analysis was also made of the relation between length of service and sickness absence in the main disease groups. Since it has been shown that the relation between sickness absence and age varied in the different disease groups and because, from general experience, one expects age to be related to length of service, it was evident that to compare crude percentages (total days lost/total days possible) would be fallacious. For example, it has been shown (Table 6) that among

TABLE 6

TYPE OF SICKNESS AND AGE

(Number of days lost expressed as a percentage of the number of working days possible)

| | | Age groups | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Married women | | | | Single women | | |
| Disease group | Group | 15–24 | 25–34 | 35–44 | 45+ | 15–24 | 25–34 | 35+ |
| Colds and influenza .. | E | 3·48 | 2·55 | 3·17 | 3·15 | 1·72 | 2·27 | 2·46 |
| | L | 1·26 | 2·16 | 5·34 | 4·90 | 1·32 | 2·29 | 3·54 |
| Respiratory system .. | E | 0·81 | 1·09 | 1·30 | 1·58 | 0·54 | 0·62 | 0·38 |
| | L | 1·67 | 0·58 | 1·09 | 2·16 | 2·19 | 2·90 | 0·00 |
| Digestive system .. .. | E | 1·85 | 1·86 | 1·24 | 0·36 | 1·30 | 1·61 | 1·27 |
| | L | 6·52 | 6·60 | 1·09 | 0·00 | 0·84 | 3·13 | 9·27 |
| Rheumatism group .. | E | 0·40 | 0·73 | 1·72 | 1·95 | 0·23 | 0·31 | 0·42 |
| | L | 0·53 | 0·24 | 0·70 | 6·11 | 0·27 | 0·00 | 8·96 |
| Circulatory system .. | E | 1·93 | 0·89 | 1·77 | 3·92 | 0·68 | 0·56 | 0·21 |
| | L | 1·72 | 2·63 | 5·88 | 1·91 | 5·30 | 0·00 | 3·75 |
| General debility .. .. | E | 1·61 | 1·16 | 0·90 | 1·03 | 0·85 | 0·75 | 0·79 |
| | L | 2·39 | 3·62 | 3·55 | 0·32 | 3·54 | 0·99 | 0·00 |
| Pregnancy .. .. .. | E | 2·25 | 2·47 | 0·35 | 0·00 | — | — | — |
| | L | 6·87 | 3·88 | 0·00 | 0·00 | — | — | — |

married women (E) the sickness absence from colds and influenza was at its peak at ages under 25. If, therefore, the group with 4 to 5 years of service included a high proportion of women under 25, this of itself would tend towards a high rate of absence from colds and influenza in this length of service group. Since, however, the tabulation of sickness rates for each length of service group, both by disease and age, was precluded by space, it was decided to use standardized rates, allowing for differences in the age distributions of the four occupation types, calculated in the same manner as the standardized death-rates used by the Registrar-General in mortality statistics.

Taking the number of possible working days (in age groups) for married (E) and single (E) combined, as our standard, the rates in Table 7 are those which would prevail for each disease and occupation group if, whilst retaining its own rate of ages, it had instead of its real population, one whose total possible working days were as in the standard adopted. By this method valid comparability of the rates in the table is assured.

These figures refute any expectation that absence due to certain types of sickness might increase with length of service. The figures for the main group (E) show, if anything, the opposite tendency, especially in the colds and influenza group (married women) and in the respiratory group (single women). In most disease groups the workers with longest service, especially married women, had the least sickness absence.

The absence figures of those who left (group L) were more variable and less reliable because of the small number of women in most length of service groups. Apart from the relatively high rate of absence of the few married women with long service in the digestive, rheumatism and circulatory groups, the women with one to four years of service usually had the most absence.

In general, the tendencies shown by these figures support the view already expressed that any increase in sickness absence due to continued employment under war-time conditions is likely to be counteracted by the progressive weeding-out of those most prone to absence. If, therefore, sickness absence were found to increase with length of employment, the results would be highly significant.

### Comments on Results

The women employed in this factory were absent from work for, on the average, approximately one working day per week. This high rate of loss was due mainly to the employment of older women and married women with their home duties, to a lowering of the physical standards of those accepted for employment, and to the stresses and strains induced by four years of war. It was also attributable in part to the specific ailments and physical disabilities of women as well as to increased susceptibility to fatigue and emotional strain.

Married women lost an average of one working week in every four but single women lost less than half this amount. This difference was not due to the higher average age of married women since, in each age group, married women lost much more time than single women and the increase was least among women over 35. It was due to the additional burdens and difficulties of married life which, judging by the results, were most severe among young married women. The high rate of absence of married women noted in this and in other investigations suggests that they have been too extensively employed in industry, and it is probable that the health of some of the younger women may have been seriously undermined by the dual task of running a home and doing factory work. A substantial portion of the total time lost was due to the frequent or prolonged absence of comparatively few women (see p. 87) and there is little doubt that most of these were unfit for full-time factory work.

The results also illustrate some of the uses of absence records providing they are accurately compiled and interpreted with care. Most factories now keep separate records for men and women, but it may also be necessary to distinguish between the absence rates of married and single women, or at least to indicate the proportions employed. Thus, taking the absence rates of married and single women as 25 per cent. and 10 per cent. respectively, the average or crude loss in a factory employing 1000 married women and 2000 single women would be 15 per cent. If, however, the proportions were reversed, the average loss would be 20 per cent. Hence, unless married and single women are employed in approximately the same proportions in different groups or factories, comparisons of absence rates may be misleading.

A somewhat similar error of interpretation may arise as the result of age differences. Thus, in the present inquiry, 263 married women were formerly employed as weavers and 218 were engaged on other factory work. Their absence rates were 20·8 per cent. and 25·3 per cent.

TABLE 7

TYPE OF SICKNESS ABSENCE AND LENGTH OF SERVICE

(Number of days lost expressed as a percentage of the number of working days possible, but adjusted to allow for differences in the age constitution of the four types of worker)

| | | Years of service | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Married women | | | | | Single women | | | | |
| Disease group | Group | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 | 0–1 | 1–2 | 2–3 | 3–4 | 4–5 |
| Colds and influenza | E | 3·92 | 3·54 | 3·33 | 2·46 | 2·75 | 1·70 | 2·21 | 1·88 | 2·25 | 1·75 |
| | L | 1·98 | 1·69 | 1·94 | 3·30 | 0·00 | 0·00 | 1·79 | 2·04 | 17·96 | 0·00 |
| Respiratory system .. | E | 0·94 | 1·49 | 0·74 | 1·13 | 0·37 | 1·12 | 0·59 | 0·53 | 0·39 | 0·28 |
| | L | 0·09 | 1·43 | 1·28 | 2·00 | 0·00 | 0·00 | 1·81 | 3·62 | 0·00 | 0·00 |
| Digestive system .. | E | 1·74 | 1·46 | 1·58 | 2·42 | 0·36 | 1·67 | 1·20 | 1·37 | 1·57 | 0·85 |
| | L | 2·82 | 4·13 | 3·23 | 7·25 | 13·32 | 2·10 | 1·62 | 5·55 | 5·26 | 0·00 |
| Rheumatism group | E | 0·44 | 0·75 | 0·94 | 0·53 | 0·17 | 0·08 | 0·34 | 0·27 | 0·30 | 0·23 |
| | L | 0·00 | 0·72 | 0·53 | 0·51 | 6·11 | 0·00 | 0·00 | 4·33 | 0·00 | 0·00 |
| Circulatory group .. | E | 2·36 | 1·73 | 1·44 | 1·98 | 0·43 | 0·70 | 0·55 | 0·62 | 0·40 | 0·53 |
| | L | 2·33 | 2·36 | 3·80 | 0·00 | 9·67 | 2·81 | 8·14 | 2·85 | 0·00 | 1·28 |
| General debility .. | E | 1·94 | 1·90 | 1·18 | 1·24 | 0·88 | 0·92 | 0·67 | 0·67 | 1·20 | 0·22 |
| | L | 3·41 | 2·23 | 2·49 | 3·54 | 1·30 | 0·00 | 3·72 | 2·47 | 1·00 | 0·00 |

respectively and it might be inferred that the former were more suitable than the latter for work in munition factories. The ex-weavers, however, as compared with the former factory workers, included a smaller proportion of younger women and a larger proportion of older women. Since younger married women had more absence than older women (Table 3), this would doubtless account for the higher absence rate of women previously employed on factory work. Similar age differences may exist among women in different factories and give rise to similar results.

This inquiry emphasizes the importance of studying the new employee from the standpoint of fitness for work; it also indicates the need for periodic examination of those accepted for employment. This procedure, combined with the information provided by individual record cards, should lead to a substantial reduction in the amount of absence from work. It must be understood that this investigation was necessarily limited to a consideration of only a few of the many factors that may cause or be associated with absence and sickness. In a complete investigation attention must, of course, also be given to the physical and psychological environment of the workers. In large factories it is advisable to compare the rates for different departments, or groups of workers, since the rate for the total population is often misleading. And home life, nutrition and transport should if possible be studied, since the health of workers is related to their whole background. This account is concerned with what should be regarded as only some of the preliminary stages of a full inquiry. It is given in some detail in the hope that industrial medical officers and personnel managers may find it useful both for its findings and for the description of the methods of analysis employed.

**Summary**

The total time lost through absence from work by the women in a factory during the last six months of 1943 was 17·5 per cent. of the number of working days possible. The corresponding figures for married and single women were 24·9 per cent. and 11·3 per cent. respectively. Married women also had a much higher rate of leaving, mainly because of ill-health and domestic difficulties. Approximately two-thirds of the total time lost was due to sickness absence and only a small proportion to absence without permission. Comparatively few women were responsible for a fairly large proportion of the total time lost.

Absence among married women was highest in the lowest age group (under 25) but among single women it tended to increase with age. In all age groups, married women lost more time than single women but the difference decreased as age increased. The rate of discharge of married women decreased up to the age of about 45 and then increased, while that of single women continued to increase in each higher age group.

There was no marked relation between absence from work and length of service. If anything, married women with less than two years of service lost more time than those employed for longer periods but the trend for single women was irregular. The relation between absence from work and length of service was affected by a progressive lowering of the standard of those accepted for employment and by the weeding out of those most prone to absence. The effect of these two factors would account for the comparatively good record of those who entered the factory before the outbreak of war. (Approximately 45 per cent. of these women were still at work at the end of 1943.)

The chief certified causes of sickness absence were colds and influenza, digestive ailments, diseases of the circulatory system, general debility and pregnancy. Absence due to these causes was particularly noticeable among married women under 25, and in some cases (digestive ailments and pregnancy) up to about 35. Absence due to diseases of the circulatory system was still more prominent among married women over 45. The relatively high rate of sickness among young married women still remained when absences due to pregnancy were excluded. Among single women, sickness absence due to colds and influenza and rheumatism increased with age, but diseases of the circulatory group showed the opposite tendency.

Women who left during the period had a much higher rate of absence through sickness, leave and without permission, than those who remained in employment. Their sickness rate was almost 30 per cent. of the number of days possible, the main causes among married women being digestive ailments and functional nervous disorders (including 'general debility'). Other causes were pregnancy, diseases of the circulatory system, colds and influenza, and genito-urinary diseases. Among single women, functional nervous disorders (including 'general debility') were the chief cause of absence and next in importance were diseases of the circulatory system and digestive ailments.

The relation between age and sickness absence in the group of leavers was often different from that of the main group who remained in employment throughout the period. The most noticeable increases in sickness absence among married leavers were in the digestive and pregnancy groups (under 35), the functional nervous (including general debility) and circulatory groups (25–45), and the rheumatism group (over 45). Among single women they were in the digestive, rheumatism and circulatory groups (over 35).

Comparisons of absence rates in different groups or factories may be misleading unless the proportions and age distributions of married and single women are taken into account.

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# ASTHMA CAUSED BY THE COMPLEX SALTS OF PLATINUM

BY

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Platinum is a rare metal of the group which includes ruthenium, rhodium, palladium, osmium and iridium. Up to 1915 almost the whole of the world's platinum production came from alluvial deposits in Russia and Colombia. In these deposits the platinum occurs as native metal alloyed with small amounts of the other metals of the group and with iron. In more recent years other sources of the platinum metals have become available. The most important new source is the nickel-copper-iron sulphide ores of the Sudbury district of Ontario, Canada, which are worked primarily for their nickel and copper contents, but which yield in addition very important amounts of the platinum metals. A second new source is the sulphide-bearing norite of the Potgietersrust and Rustenburg districts of the Transvaal. In the Sudbury ores the platinum is present chiefly in combination with arsenic, and in the South African ores it is combined with sulphur. New alluvial deposits have also been developed in Alaska, Abyssinia and elsewhere.

Platinum and its alloys are manufactured into sheet and wire for use in jewellery, dentistry, and the chemical and electrical industries. These products are made chiefly by the usual metallurgical processes of melting, casting, forging, rolling, and wire drawing. Recently, however, the increased production of finely divided metal powders from complex platinum salts has led to increased handling of these salts in the precious metal industry.

Of the many and varied uses of platinum, attention is directed here more particularly to the use of the platinum salts and their aqueous solutions. The chemical industry handles considerable quantities of hexachloroplatinic acid, $H_2PtCl_6$, in the manufacture of platinum catalysts. The electroplating industry deposits platinum from aqueous solutions containing various platinum salts such as sodium hexahydroxy-platinate $Na_2Pt(OH)_6$, dinitrodiammino platinum ($Pt2NH_3(NO_2)_2$), and from phosphate solutions.

In photography use is made of a paper sensitized with a mixture of potassium chloroplatinite $K_2PtCl_4$, and ferric oxalate. Barium platino-cyanide $BaPt(CN)_4$, is used in x-ray fluorescent screens. In opthalmology Duggen and Narravala (1941) described the use of platinum chloride for the tattooing of opacities in the cornea. Stenius (1941) used it as a histological method for staining the visual purple.

The literature of the toxicology and pharmacology of platinum and its salts is scanty. The first mention is made in 1827 when Gmélin described the effects of platinum chloride on animals. Prévost (1833) described its use in the treatment of epilepsy. Hofer (1840) advocated the use of platinum perchloride ($PtCl_4$) and sodium chloroplatinite ($Na_2PtCl_6$) in the treatment of syphilis Pedler (1878) showed that platinum perchloride inactivates cobra venom in vitro, though Brunton and Fayrer (1878) pointed out that this was due to the formation of an insoluble compound with cobra poison and not to any action of platinum itself. The platinum perchloride is a chemical antidote and has no power to modify or prevent the action of the venom after its absorption into the blood. Carozzi (1934) gave an account of a chemist who developed discomfort, weakness, vertigo, and a remarkable acceleration of respiration and pulse rates about two hours after watching spongy platinum melted in refractory crucibles. White fumes which rose from the crucible, when heated with an oxyhydrogen flame, turned green. The platinum had been prepared from the residues of gold-bearing ores from Russia containing tellurium and other impurities.

Hofmeister (1882) described experiments showing the toxic effects of platinum ammine chlorides on frogs and rabbits. He showed that they first caused an increase of reflex sensitivity and even convulsions, and later fibrillary twitchings and a 'curare'-like paresis of the nerve endings in muscle. In the rabbits there were also epileptiform seizures and loss of consciousness. Hardman and Wright (1896) reported the death of a child aged 7 months who died five hours after the accidental administration of 8 gr. of potassium chloroplatinite. The child had previously been ill and a necropsy revealed a chronic ileo-colic intussusception. Chemical analysis detected the presence of platinum in the stomach and duodenum, but it was not present in any other organ. The immediate cause of death was considered to be cardiac syncope; but since the child was described as being in a feeble state of health, the case does not contribute much to present knowledge of the toxicology of platinum salts. The only reference to any toxic effect in adults is by Karasek and Karasek (1911) who in examining the workers in forty photographic studios in Chicago found eight cases of poisoning characterized by pronounced irritation of the throat and nasal passages, causing violent sneezing and coughing. There was also bronchial irritation causing respiratory difficulties so great that some individuals were entirely unable to use the paper containing potassium chloroplatinite Irritation of the skin causing cracking, bleeding and pain, was also observed

### Environmental Conditions in Platinum Refineries

A full account is given of the metallurgy and methods of refining of the precious metals in the Imperial Institute reports on the mineral industry of the British Empire and foreign countries (1936); and in 1937 Johnson and Atkinson recorded the method used at the Acton refinery of the Mond Nickel Company (fig. 1). Whatever method is used in refining, the platinum is precipitated in the form of one of its complex salts, either ammonium chloro-

FIG. 1.—Wet-process department in Acton refinery of the Mond Nickel Company.

platinite $(NH_4)_2PtCl_6$, which is then ignited to produce platinum sponge, or sodium chloroplatinite $Na_2PtCl_66H_2O$. The platinum sponge may then be sieved preparatory to further treatment. Sometimes the complex salts are handled in dry form and sometimes in a wet process. If they get into the atmosphere in the dry process it is in the form of dust, and in certain stages of the wet process they are thrown into the atmosphere in the form of droplets in a fine spray. The process of sieving the spongy platinum causes a dust of metallic platinum. The environmental conditions have been investigated in four refineries. At refinery A, a wet process involving sodium chloroplatinate was in operation; at refinery B a wet process caused the precipitation of ammonium chloroplatinate which was then dried; at refinery C dry ammonium chloroplatinate was handled, mostly under excellent exhaust ventilation, though where the salt was crushed this was less good, and at refinery D ammonium chloroplatinate, after precipitation, was ignited to form spongy platinum. The whole operation was carried out under exhaust ventilation, there being no anxiety about loss since the precious metals were recovered from the exhaust by an electro-static precipitator.

### Estimation of Platinum Salts and Metal in Low Concentrations

The platinum content of the atmosphere at various points in these refineries was estimated. A volume of air was sucked through a particulate filter at a known flow-rate for a given time, usually during the whole of an operation. Air-borne concentrations of platinum dusts encountered in the process laboratories and factories may consist of soluble platinum salts, platinum metal or platinum metal mixed with other precious metals. If a mixture of precious metals was present, the following technique was employed.

*Principle.* The particulate filter with the mixture of precious metals was digested with aqua regia and brought into solution. Thallium nitrate was then added to form a thallium complex of the precious metals; this was rendered alkaline with ammonia, when the complexes of all the metals except platinum were dissolved and removed. The platinum complex was then dissolved off the paper with acid, and reduced to the platinous state by the addition of stannous chloride. Estimation of the orange colour of the platinous chloride by the colorimetric method of Snell and Snell (1936), gave a quantitative measurement of the concentration of platinum.

*Technique.* (i) The filter pad containing the dust sample was placed in a Kjeldahl flask and thoroughly digested with a few millilitres of aqua regia. The contents of the flask were then heated almost to dryness, care being taken not to char the digest. 20–30 ml. of water were added, together with a few drops of a 1 per cent. solution of thallium nitrate. After the formation of the thallium complex was complete, the solution was rendered alkaline with ammonium hydroxide and filtered. The filter paper was thoroughly washed with ammonia to remove all traces of the salts of extraneous metals.

(ii) The filter containing the platinum-thallium complex was then subjected to a further aqua regia digestion and carefully heated almost to dryness as before. A few millilitres of concentrated hydrochloric acid were added and the solution was boiled again to remove all traces of nitric acid. If necessary a second boiling with hydrochloric acid was carried out. To remove the hydrochloric acid the solution was evaporated to dryness and redissolved in water, and twice again evaporated to dryness.

(iii) The sample was then dissolved in a known volume of 3·3 per cent., by volume, solution of hydrochloric acid in distilled water and filtered. If this solution showed any yellow colour from the nitration of the filter paper, this colour was measured by the Hilger Spekker photo-electric colorimeter, and the reading subtracted from the reading obtained, later, after the development of the platinum colour. To 10 ml. of this solution (or an aliquot diluted to 10 ml. with the hydrochloric acid solution) was added 0·1 ml. of 40 per cent. stannous chloride ($SnCl_2$) in concentrated hydrochloric acid. The presence of platinum was shown by the development of a yellow-orange colour, which after 15 minutes development time was related to the amount of platinum in solution within a range of 10–500$\mu$g ($\mu$g is 1/1000 mg.). If greater sensitivity was required, the solution after filtering was heated to dryness, and then dissolved in 5 ml. of the solution. In this way the method was made twice as sensitive as that already described. Even greater sensitivity may be obtained by dissolving the salt in 2·0 ml. of hydrochloric acid and taking readings on a sensitive photo-electric colorimeter with a mirror galvanometer. This micro-reading technique will give estimations as low as 0·5$\mu$g of platinum in solution. It is, however, so delicate that it is difficult to apply in the presence of large amounts of residue from filter paper digestion.

*Calibration Curves.* (Figs. 2 and 3.)

(*a*) Using Spekker colorimeter, with 10-ml. cup and dark blue filters.

| $\mu$g Pt. | Spk. reading | $\mu$g Pt. | Spk. reading |
|---|---|---|---|
| 0 | 0 | 200 | 48 |
| 20 | 5 | 250 | 58 |
| 50 | 11 | 300 | 67 |
| 100 | 25 | 400 | 82 |
| 150 | 34 | 500 | 94 |

(*b*) Using micro-photometer with 2-ml. cups and violet figures.

| $\mu$g Pt. | Galvanometer difference | $\mu$g Pt. | Galvanometer difference |
|---|---|---|---|
| 0·0 | 0·0 | 2·0 | 11·2 |
| 0·5 | 3·5 | 2·5 | 13·0 |
| 1·0 | 6·5 | 3·0 | 14·6 |
| 1·5 | 9·2 | 3·5 | 15·8 |

*Calibration Curve using Spekker Colorimeter with 10-ml. Cup and Dark Blue Filters.*

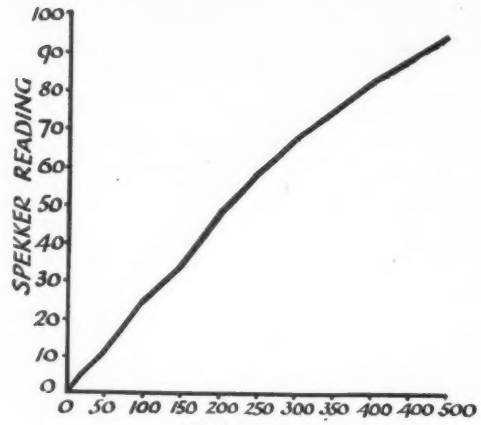


FIG. 2.

*Calibration Curve using Micro-Photometer with 2-ml. Cups and Violet Filters.*

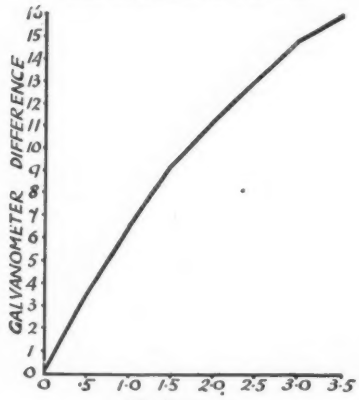


FIG. 3.

When the sample consisted only of soluble platinum salts the filter pad was digested with concentrated hydrochloric acid. The solution so obtained was diluted and filtered. It was then evaporated to dryness twice, after being dissolved in water, to remove excess hydrochloric acid. The platinum was then estimated by the colorimeter technique described in paragraph (iii) above.

When the sample contained metallic platinum, but no other precious metals, it was not necessary to carry out the process described in paragraph (i), but the estimation was made according to the technique described in paragraphs (ii) and (iii).

| | | |
|---|---|---|
| A. 1. | Neutralizing platinum salts .. .. | 18 μg/m³ |
| 2. | " " " .. .. | 20 " |
| 3. | Separating crystals of platinum salts | 7 " |
| 4. | " " " " | 9·3 " |
| 5. | " " " " | 9·5 " |
| 6. | Sieving spongy platinum metal .. | 400 " |
| B. 1. | Aqua regia treatment of crude platinum metals concentrate .. .. | 2·0 μg/m³ |
| 2. | Precipitation and filtration of impure $(NH_4)_2PtCl_6$ .. .. .. | 3·4 " |
| 3. | Dissolving impure platinum sponge in aqua regia .. .. .. | 3·6 " |
| 4. | Precipitation and filtration of pure $(NH_4)_2PtCl_6$ .. .. .. | 1·6 " |
| 5. | Discharging dry $(NH_4)_2PtCl_6$ from drying ovens .. .. .. | 50·2 " |
| 6. | Hand crushing and packing dry $(NH_4)_2PtCl_6$ and $(Pd2NH_3Cl_2)$ in ashless filter paper. | |
| 7. | Precipitation and filtration of impure $(Pt2NH_3Cl_2)$ .. .. .. | 2·0 " |
| 8. | Purification of rhodium .. .. | 6·9 " |
| 9. | Recovery of small amounts of precious metals from solutions by zinc reduction .. .. .. | 3·1 " |
| 10. | Discharging residues from drying ovens .. .. .. .. | 4·1 " |
| C. 1. | Crushing ammonium chloroplatinate | 1700 μg/m³ |
| 2. | Atmosphere near reducing furnace .. | 6 " |
| 3. | Aqua regia attack on platinum .. | 1·5 " |
| 4. | Sieving spongy platinum .. .. | 960 " |
| D. 1. | Aqua regia attack on platinum metal | 1·0 μg/m³ |
| 2. | " " " " | 0·9 " |
| 3. | Atmosphere near reducing bath furnace .. .. .. .. .. | 3·2 " |
| 4. | General atmosphere of P.M. dept. .. | 2·0 " |

In refinery B, estimations were also made by spectrographic methods described by Fothergill, Withers and Clements (1945), and similar figures were obtained at the same sampling points.

### Investigation of Workers

All the workers in these four refineries were interviewed. The history of any illness involving nasal or chest symptoms was obtained. Their occupational history was taken, and any family history of asthma was noted. They were examined clinically, and 15 in. × 12 in. radiographs were taken of their chests. Full blood counts were obtained from all of them. An attempt was made at refinery A to test their skin sensitivity by injecting intradermally 2 minims of a 1/10,000 solution of sodium chloroplatinate. Unfortunately nearly half the workers refused this test, apparently owing to a fear of becoming sensitive to the salt. In the rest the intradermal test was unsatisfactory; and at refinery B a patch test had been previously tried and had given equivocal results. Skin tests were therefore not persisted with in refineries B, C and D.

The age and sex of the employees in the four refineries were as follows:—

| Refinery | 29 and under | 30–39 | 40–49 | 50–59 | Over 60 | Total |
|---|---|---|---|---|---|---|
| A male .. | 5 | 4 | 4 | 6 | 1 | 20 |
| female .. | — | 3 | 1 | — | — | 4 |
| B male .. | 10 | 19 | 30 | 13 | 2 | 74 |
| C male .. | 3 | 2 | 2 | 1 | — | 8 |
| female .. | 1 | — | — | — | — | 1 |
| D male .. | 1 | 2 | 2 | 2 | — | 7 |
| Total .. | 20 | 30 | 39 | 22 | 3 | 114 |

They had worked in platinum refineries for the following number of years :—

| Refinery | 4 and under | 5–9 | 10–14 | 15–19 | 20–24 | 25 and over | Total |
|---|---|---|---|---|---|---|---|
| A | 6 | 4 | 1 | 3 | 4 | 6 | 24 |
| B | 12 | 13 | 7 | 13 | 18 | 11 | 74 |
| C | 8 | 1 | — | — | — | — | 9 |
| D | 1 | 2 | 1 | — | 2 | 1 | 7 |
| Total | 27 | 20 | 9 | 16 | 24 | 18 | 114 |

Many of the men in these refineries suffered from a syndrome similar to that described by the Karaseks in Chicago in 1911. It started with repeated sneezing and was followed by profuse running of the nose with a watery mucous discharge. Then followed tightness of the chest, shortness of breath, cyanosis and a wheeze. These symptoms would persist so long as the men were in the factory and for about one hour after they left. The symptoms would then subside, but often the man would wake in the early hours of the morning with a bout of coughing which might last half an hour. A compensatory polycythaemia was observed in one man seen during an attack. Some men also complained of a scaly erythematous dermatitis, and some of an urticarial rash. The following case histories are given as examples of the syndrome.

*Case* 1. R. C., aet. 58, research chemist, worked in refinery A from 1907 to 1924 (18 years). From the first year at this work he noticed a tightness of the chest with a wheeze when certain processes in the refinery which caused a spray were in operation. He noticed a tightening also in the muscles of the back and marked sneezing. There was a watering of the eyes and a dislike of light. He would go home and go straight to bed, and would wake up in the morning quite fit, only to repeat the same symptoms the next day. He was forced to leave the refinery in 1924 because the symptoms became so bad he could no longer carry on. Since then he has been perfectly well. On one occasion he returned to the refinery on business and immediately noticed a tightness of his chest, even though the process to which he was sensitive was not going on in the room. However, it was discovered that sodium chloroplatinate had been weighed out in the room about half an hour previously. There was no family history of asthma. He now showed no abnormal physical signs. His blood count was 4,160,000 red cells per c.c., haemoglobin 111 per cent. (photo-electric estimation of alkaline haematin 100 per cent., equivalent to 13·8 gm. haemoglobin per cent.), white cells 12,200, polymorphs 61 per cent., small lymphocytes 6 per cent., large lymphocytes 27 per cent., large hyalines 6 per cent. Dr. D. Jennings reported on an x-ray of his chest—old bilateral apical infection with fibrosis and drawing upward of both hila; emphysema of both bases.

*Case* 2. A. W., male, aet. 38, started work at the age of 15 in a chocolate manufacturing factory. He worked here for 6 months and then transferred to platinum refinery A. After six years on this work he noticed that when certain processes were in operation his nose started to run and he would start sneezing. This lasted for half an hour. The symptoms gradually got worse and after ten years he began to get tightness of his chest, shortness of breath, wheeze and cough, but he produced no sputum. He never had an attack at home. The attacks gradually got more frequent and more severe, and two months before he was interviewed he was moved to the ' other precious metals ' department. Since this move he has not had a further attack. He had had no previous illness, and there was no family history of asthma. On examination no abnormal physical signs were found, except that when he painted a 3 per cent. solution of sodium chloroplatinate on his forearm a large wheal appeared. His blood count showed 5,120,000 red cells, 100 per cent. haemoglobin (photo-electric estimation), 11,200 white cells, 50 per cent. polymorphs, 41 per cent. lymphocytes, 3·5 per cent. eosinophils, 5·5 per cent monocytes. X-rays of his chest showed emphysema.

*Case* 3. E. V. N., chest, assistant manager of wet process at refinery B, aet. 28, had worked for five years in the laboratory and for 2½ years as assistant manager of the wet process. Immediately he started on the process he became aware that if he entered the room where ammonium chloroplatinate was dried his nose started to run, producing perfectly clear fluid. He would soak three handkerchiefs in an hour. He would develop severe sneezing attacks and some irritation of his eyes. After he had been there three months these symptoms were followed by tightness of the chest which would last for half an hour, and wheezing which lasted 5 hours. He would be awakened in the early hours of the morning with a cough which might last an hour, but the following day he would be quite fit. He had had no previous illness, and there was no family history of asthma. He entered the drying-room on the day he was interviewed and was observed in an attack. He was cyanosed, dyspnoeic and had an audible wheeze. His respiration rate was 34. He had no clubbing of his fingers. His chest moved evenly, was hyper-resonant with normal air entry but many sibilant rhonchi throughout. There were no other abnormal physical signs. His blood count showed 6,350,000 red cells, 130 per cent. haemoglobin (photo-electric estimation), 8200 white cells, 60 per cent. polymorphs, 30 per cent. lymphocytes, 5 per cent. eosinophils, 1 per cent. basophils and 4 per cent. monocytes. X-ray of his chest revealed no abnormality. During the attack he was given 10 minims of 1/1000 adrenalin intramuscularly, but it did not produce any relief of the symptoms, though it raised the pulse rate from 80 to 120.

*Case* 4 L. J., aet. 36, process hand, worked 7 years at a chemical plant and then for 14 years at platinum refinery B on the wet process and in the ' other precious metals ' department. During the past 3 years he had had attacks of running nose, sneezing, shortness of breath, tightness of the chest, wheeze and cough. He was frequently awakened by attacks of coughing at 2 a.m., and had had such an attack every night for the three months previous to his sick-leave which had lasted 3 weeks at the time of interview. He had never had any attacks while away from the works. He was moved to the time office, but still got some attacks, and was therefore transferred to another department where he would not be exposed to the salts of platinum. He had had pleurisy at the age of 8, and had his tonsils removed 1 year previously because of his asthma. There was no family history of asthma. When examined he had not been at the refinery for three weeks, so he appeared a healthy man, and showed no abnormal physical signs. His blood count showed 4,760,000 red cells, 104 per cent. haemoglobin (photo-electric estimation), 7450 white cells, 57 per cent. polymorphs, 1·5 per cent. eosinophils, 39·5 per cent. lymphocytes and 2 per cent. monocytes. Dr. M. H. Jupe reported on an x-ray of his chest as follows:—' There are a few scattered calcified nodules over the lung fields. The hilar shadows are well seen, but not excessive.'

*Case* 5. M. D., female, aet. 20, had worked as a press operator before entering platinum refinery C; 3 months before her interview she was observed sieving spongy platinum without exhaust ventilation or mask, and was seen to be without any symptoms. She said that when she handled the dry complex salt her eyes and nose would run, and she sneezed continuously. She experienced some tightness of the chest the same evening, but this never woke her at night. She had never been ill, and had no family history of asthma. On examina-

tion she had no abnormal physical signs. Her blood count showed 4,500,000 red cells, 98 per cent. haemoglobin (photo-electric estimaton), 12,000 white cells, 58 per cent. polymorphs, 2 per cent. eosinophils, 34 per cent. lymphocytes, 6 per cent. monocytes. X-ray of her chest revealed no abnormality.

*Case* 6. A. A., chemist, aet 33, for past 4 years had been in charge of platinum refinery D. For 12 years before that he had been an analytical chemist. He had no symptoms except when he treated the filtrates with granulated zinc; this caused effervescence and droplets containing complex salts to be thrown into the atmosphere Then his nose ran and he sneezed. This might last for half an hour. He had no tightness of his chest, shortness of breath, cough or wheeze. He had had scarlet fever as a child, but there was no family history of asthma. On examination, apart from a very mild degree of funnel chest, he had no abnormal physical signs. His blood count showed 5,950,000 red cells, 118 per cent. haemoglobin (photo-electric estimation), 7000 white cells, 60 per cent. polymorphs, 36 per cent. lymphocytes, 1 per cent. eosinophils, and 3 per cent. monocytes.

Analysis of the occupation of the workers who complained of these symptoms and of the circumstances in which they occurred, produced conclusive evidence that the complex salts of platinum are the cause of the syndrome. The sieving of spongy platinum produces a much higher concentration of platinum in the atmosphere than the processes involving the complex salts. Workers have been observed sitting over this process without exhaust ventilation and without wearing masks; yet in no instance has asthma been found to arise among workers while engaged on this sieving. In two instances in refinery A and in three instances in refinery B, workers who complained of asthma were removed from the platinum refining department to the 'other precious metals' department, where they handled principally ruthenium and rhodium without recurrence of the symptoms. The incidence was highest in those in contact with the complex salts in their dry form, but did occur also in those engaged on certain parts of the wet processes where droplets of the complex salts were thrown into the atmosphere. Maintenance men and men engaged on packing the complex salts stressed the fact that the dust immediately produced the symptoms described. In refinery C the symptoms were most severe where the salt was crushed, and at this point the complex salt concentration in the atmosphere was exceptionally high. It was interesting that the authorities at refineries A, B and C were well aware that the syndrome had been occurring in their refineries for many years, yet those at refinery D had never heard of it. On investigation the explanation was evident. At refinery D the ammonium complex salt was precipitated under exhaust ventilation, and then ignited to form spongy platinum, again with exhaust ventilation. Loss of the precious metal was not considered since it was trapped from the exhaust and recovered by an electro-static precipitator. There was thus no dust and no spray. There was, however, in this refinery, a process in which the filtrates were treated with granulated zinc, and there was a fine spray and no exhaust ventilation. The men were only in contact with the process for a few minutes at a time, and while none complained of shortness of breath, tightness of the chest or wheeze, 5 out of 7 said they noticed sneezing and running of the nose of short duration.

Analysis of occupation and symptoms showed that out of 91 men in contact with the complex salts of platinum, 52 have the asthmatic syndrome to some degree. The following table (Table 1)

TABLE 1

| Refinery | Number employed | Occupation in refinery | Number with asthma | Number with dermatitis | X-ray of chest | | Number showing eosinophilia above 300 per c.c. | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Number with emphysema | Number with calcified costal cartilage | Handling double salts | Not handling double salts |
| A | 24 | Manager .. 1 | 0 | — | — | — | — | — |
| | | Ceramic Dept. 1 | 1* | — | 1* | — | 1* | — |
| | | Bullion Dept. 1 | 1* | — | 1* | — | 1* | — |
| | | Wet process .. 18 | 6 | 3 | 1 | — | 2 | — |
| | | Maintenance 1 | 1 | — | — | — | — | — |
| | | O.P.M. .. 2 | 2* | — | 2* | — | 1* | — |
| B | 74 | Manager .. 3 | 3 | — | 1 | 1 | 2 | — |
| | | Wet process .. 29 | 14 | 3 | 3 | 5 | 7 | 6 |
| | | Ignition and drying-rooms 4 | 3 | 1 | — | — | 2 | — |
| | | Packing salt .. 2 | 2 | 1 | — | — | 1 | — |
| | | Maintenance 10 | 4 | — | 1 | — | 1 | — |
| | | Laboratory .. 12 | 1† | — | — | — | — | 5 |
| | | Furnace .. 6 | — | — | — | — | — | 4 |
| | | O.P.M. .. 8 | 3* | 3* | 1 | — | 2 | 4 |
| C | 9 | Dry process .. 9 | 6 | 2 | — | — | 3 | — |
| D | 7 | All processes 7 | 5‡ | — | — | — | — | — |
| Total .. | 114 | Number in contact with complex salts of platinum .. 91 | 52 | 13 | 11 | 6 | 24 | 19 |

* Developed syndrome on wet process and moved to another department with complete relief.
† Handles complex salts of platinum.
‡ Mild symptoms of running nose and sneezing when on process producing spray.

gives the data of this analysis, as well as information on radiographic evidence of emphysema and calcification of the costal cartilages, and the numbers of workers with a total eosinophil count in the blood above 300 per c.c.

Of the men examined, 13 had suffered from skin lesions: these were mostly of a scaly erythematous type, though some were urticarial. They were confined to the parts of the body exposed either to dust or spray, involving principally the hands and forearms, but in the more severe cases the face and neck were also involved. The condition was not materially different from that which might be found in any chemical factory and diagnosed under the general heading, 'industrial dermatitis.' One of the workers at refinery A was so sensitive that on painting a 3 per cent. solution of sodium chloroplatinate on his arm a well marked wheal appeared within two minutes. Skin tests, which were carried out in refinery A by injecting intradermally 2 minims of a 1/10,000 solution of sodium chloroplatinate, gave little information. The results are shown in Table 2.

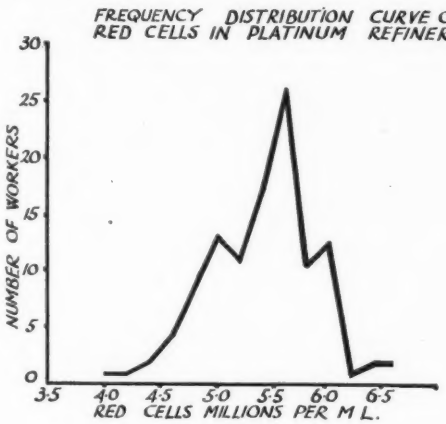


FIG. 4.

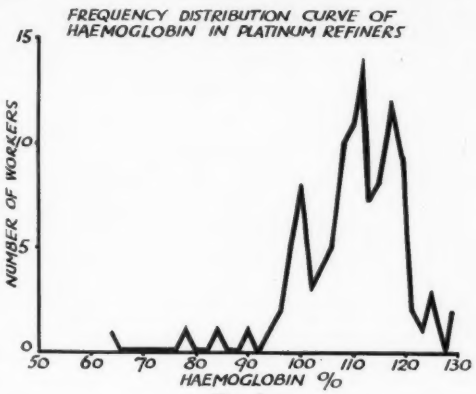


FIG. 5.

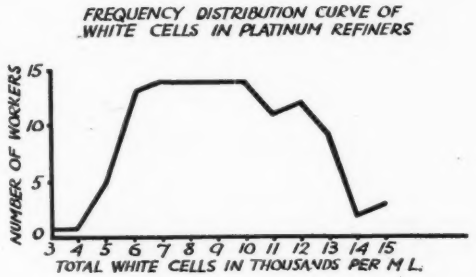


FIG. 6.

Examination of the x-ray films of the chest of this group of workers revealed nothing outstanding. It would be expected that emphysema would develop in those who had repeated attacks of asthma, and the incidence of radiological signs of emphysema and catarrhal bronchitis is high. Another observation was that in 6 instances there was gross calcification of the costal cartilages. This incidence is probably higher than would be found in a similar group of the population at large. Evidence of

TABLE 2

| Case No. | Sex | Age | Symptoms | Skin test results | | |
|---|---|---|---|---|---|---|
| | | | | Immediate | 24 hours | 48 hours |
| 1036 | M | 38 | Asthma | 3-mm. wheal | Nil | Nil |
| 1037 | M | 29 | Nil | Nil | ,, | ,, |
| 1038 | M | 64 | ,, | 5-mm. wheal. | ,, | ,, |
| 1039 | M | 54 | ,, | Nil | ,, | ,, |
| 1042 | M | 31 | Running of nose | ,, | ,, | ,, |
| 1043 | M | 35 | Asthma | ,, | 2·5-mm. wheal | ,, |
| 1044 | M | 56 | ,, | ,, | 3-mm. wheal | ,, |
| 1045 | M | 45 | Dermatitis | 15-mm. wheal | Nil | ,, |
| 1050 | M | 51 | Nil | Nil | 6-mm. wheal | 6-mm. wheal |
| 1051 | M | 49 | Asthma and dermatitis | ,, | Nil | Nil |
| 1052 | M | 56 | Asthma | ,, | ,, | ,, |
| 1053 | M | 55 | ,, | ,, | 4-mm. wheal | ,, |
| 1054 | M | 43 | ,, | ,, | 3-mm. wheal | ,, |
| 1055 | F | 48 | ,, | ,, | 4-mm. wheal | ,, |
| 1056 | F | 33 | ,, | 5-mm. wheal | Nil | ,, |
| 1058 | F | 39 | Nil | Nil | ,, | ,, |

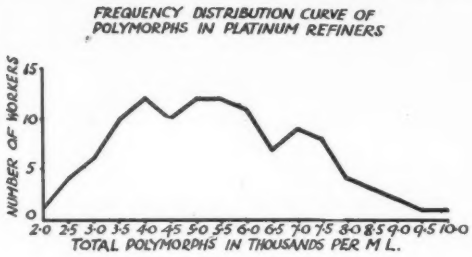
FREQUENCY DISTRIBUTION CURVE OF POLYMORPHS IN PLATINUM REFINERS
NUMBER OF WORKERS
15
10
5
0
2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 8·5 9·0 9·5 10·0
TOTAL POLYMORPHS IN THOUSANDS PER M L.

FIG. 7.

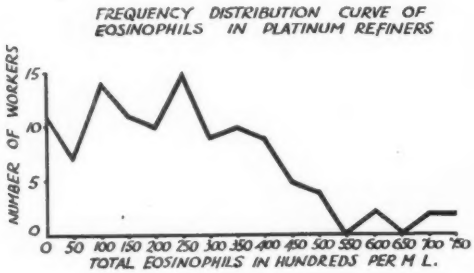
FREQUENCY DISTRIBUTION CURVE OF EOSINOPHILS IN PLATINUM REFINERS
NUMBER OF WORKERS
15
10
5
0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750
TOTAL EOSINOPHILS IN HUNDREDS PER M L.

FIG. 8.

arrested or calcified pulmonary tuberculosis was found in 5 instances, and active disease was present in one instance.

The blood counts revealed normal red cell counts and haemoglobin levels, except for case 3 who was observed in an attack, and had a marked compensatory polycythaemia. There is, however, a tendency towards a polymorphonuclear leucocytosis, but this is probably of no significance since the range of variation in white cell counts in the industrial population during the war has been wide. The eosinophil counts tend to be high, but none are extremely high. Frequency distribution curves have been drawn from all these figures.

### Prevention and Treatment

Prevention of this syndrome can be achieved by not allowing the complex salts of platinum to reach the atmosphere of the workshop, either in the form of dust or spray. This can be achieved by exhaust ventilation. Dust is worse than spray; therefore, unless it is necessary for technical reasons, it is advisable that the double salts of platinum should not be dried. Masks give some protection, but since they introduce the human factor, they are unsatisfactory.

Treatment consists of removal from exposure to the dust or spray. It is advisable to wash away the salts from the nose with water. Fresh air relieves the symptoms more quickly than anything else. Oxygen may help to relieve symptoms; and Adrenalin injected intramuscularly may help to relieve a severe attack.

### Summary

A syndrome consisting of running of the nose, sneezing, tightness of the chest, shortness of breath, cyanosis, wheezing and cough is described.

This syndrome occurred in 52 out of 91 men exposed to the dust or spray of the complex salts of platinum.

Thirteen men complained of dermatitis.

These syndromes did not arise in men exposed to much higher concentrations of metallic platinum in the atmosphere, or to men exposed to the complex salts of the other precious metals, including palladium.

Prevention is by exhaust ventilation.

### Acknowledgments

We should like to express our gratitude to the precious metal refining companies and their managers for their courtesy in allowing us to carry out this investigation, and for their help during it.

We are indebted to Dr. James Maxwell, Mr. A. Parker Hague and Dr. A. J. Amor for drawing our attention to the existence of the condition, to Dr. M. H. Jupe and Dr. D. Jennings for reporting on the radiographs, to Mr. H. J. Ferrier for taking them, and to Mr. W. D. Duffield and Mr. L. Hoskins for technical help.

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# DETERMINATION OF TRACES OF PLATINUM AND PALLADIUM IN THE ATMOSPHERE OF A PLATINUM REFINERY

## BY A COMBINED CHEMICAL AND SPECTROGRAPHIC METHOD

BY

S. J. R. FOTHERGILL, D. F. WITHERS and F. S. CLEMENTS

An investigation carried out by Hunter and others (1945) on the health of workers at the refinery of the Mond Nickel Co., Ltd., Bashley Road, London, N.W.10, made it necessary to estimate the atmospheric content of platinum and palladium in the neighbourhood of various unit processes. The method of sampling the atmosphere and the collection of the precious metals on a particulate filter is described by Hunter and his colleagues. But we were more particularly concerned with the estimation of the traces of platinum and palladium collected on the particulate filter pads. The principle of the method we used was to collect the precious metals in a silver bead by standard smelting methods followed by cupellation and then to estimate the platinum and palladium in the silver bead spectrographically.

In 1938 Seath and Beamish published a paper entitled 'Spectrographic Examination of Assay Beads for Platinum, Palladium and Gold.' The precious metals were collected in a silver bead by smelting methods and the beads were examined spectrographically, comparison being made with standards prepared in the following way:

Lead containers were made from spectrographically pure lead foil. Solutions of precious metals were added to these from micro-burettes. After evaporating the solutions the boxes were rolled up with a weighed amount of silver foil, wrapped in more lead foil and compressed under a pressure of 100 kg. per sq. cm. The resulting 30 gm. cylinders were cupelled at 900° C. and the beads left in the muffle for 2 minutes after the 'blick' to remove most of the lead.

For the production of arc spectra the operating conditions were: current, 2 amperes; arc gap, 3 mm.; exposures, 2 minutes. Graphite electrodes 6·3 mm. diameter were used and the lower electrode was made the anode. The weight of each bead was 10 mgm. and the authors claim a sensitivity of 0·004 per cent. for platinum, using the line 3064·7A and 0·001 per cent. for palladium, using the line 3404·6A.

### Laboratory Work

#### (1) Preparation of Standards

A series of silver standards containing known amounts of platinum and palladium were prepared in the form of wires. These standards were prepared by the Research and Development Department of the Mond Nickel Company and had the following compositions:

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Platinum per cent. | 0·001 | 0·003 | 0·01 | 0·03 | 0·10 | 1·0 |
| Palladium per cent. | 0·001 | 0·003 | 0·01 | 0·03 | 0·10 | 1·0 |

The diameter of the wires was 0·056 in. and a length of 6 mm. weighed approximately 100 mgm.

All melting operations required for the preparation of the standard alloys were carried out in graphite crucibles and the molten alloys were cast into graphite moulds. The use of graphite for these operations is important because it is shown later that contact of molten silver with refractories such as alumina and magnesia affects the arcing properties of silver.

Uniformity in composition of the wires was ensured by thorough annealing at various stages in drawing the wires.

#### (2) Spectrographic Examination of the Standards

Portions of 100 mgm. of each standard were arced using a current of 2 amperes and exposure time 2 minutes. The arc gap was 4 mm. and the silver bead formed the anode.

The lowest limits detected under these conditions were:

Platinum .. 0·003 per cent. (Line used: 3064·7A)
Palladium .. 0·001 per cent. (Line used: 3404·6A)

In order to see whether the process of cupellation had any effect on the behaviour of silver beads in the arc, portions of the standards were cupelled with 5 gm. of assay lead on Mabor cupels. The cupelled beads were cleaned in hydrofluoric and 1 : 1 hydrochloric acids and then submitted to the arcing treatment described above.

It was immediately noticed that the arcing behaviour of the cupelled beads differed from the original standards in that the green colour of the arc was not so strong, and usually faded right out after about 15 seconds. The arc then had the appearance of that produced by graphite electrodes alone.

Examination of the spectra showed that the intensities of the platinum and palladium lines had been affected to such an extent that, at the 0·1 per cent. level, Pt 3064·7 was only barely visible and Pd 3404·6 was not detected at all.

Thus the process of cupellation has a marked influence on the behaviour of beads in the arc.

A further experiment showed that even when the standards are simply melted on a Mabor cupel, without the addition of any lead, the same lack of sensitivity results. With 0·1 per cent. platinum and palladium standards neither element could be detected.

The cupellation experiments were repeated using bone ash in place of Mabor cupels and the beads cleaned as above and examined. The green colour of the arc did not persist for more than 15 seconds and an imperfect reproduction of the silver spectrum was obtained.

The lack of sensitivity observed in these experiments is most probably connected with the fact that the cupelled beads, on arcing, only lose a very small amount of metal by volatilization. In one test with a cupelled bead from standard 'E' only 1·1 mgm. was lost, whereas with the original wire 9·1 mgm. were volatilized.

It is possible that a thin film of refractory oxide is formed on the surface of the molten bead which prevents the arc from coming into contact with the silver itself.

In order to study this matter further the effect of various pure refractory oxides was investigated.

Three sets of cupels were prepared, each set having one of the following materials forming its top surface: (*a*) alumina, (*b*) lime, (*c*) magnesia. Portions of the standards 'C,' 'D' and 'E' were melted on each type of refractory, and the beads, after cleaning, were arced in comparison with the original wire standards.

The bead spectra all showed reduction in the strength of the platinum and palladium lines, the effect being most marked in the case of those beads which were melted on the alumina surface and least marked where melting was done on a magnesia surface.

### (3) Chemical Treatment of Beads before Arcing

Since it appeared that the abnormal behaviour of the cupelled beads might be due to some impurity picked up during the cupellation, it was decided to attempt to remove such impurities by a chemical treatment of the beads.

After a preliminary cleaning in hydrofluoric acid and in hot 1 : 1 hydrochloric acid the beads were treated by one of the following methods:

(*a*) The bead was dissolved in nitric acid in a small crucible, the silver was precipitated as chloride and the entire contents of the crucible were evaporated to dryness. The platinum and palladium chlorides were thus collected on the silver chloride. The dried precipitate and wipings from the crucible were wrapped in a 7-cm. filter paper and ignited to metal in hydrogen.

(*b*) The bead was dissolved in a minimum of concentrated sulphuric acid and the excess acid driven off by heating. The dry silver sulphate was dissolved in boiling water and the silver and precious metals were precipitated with hydrazine sulphate. It was found that complete precipitation of the silver could be obtained only if the solution was finally made ammoniacal. The precipitate was filtered on a 7-cm. paper, dried, ignited and reduced in hydrogen.

(*c*) The bead was dissolved in a minimum of concentrated sulphuric acid, the solution diluted and the metals precipitated from the boiling solution with hydrogen sulphide. The precipitate was filtered on double 7-cm. paper, washed with hot distilled water, dried and ignited carefully to metal in air.

Spectrographic examination of the metals obtained by these three methods was carried out without difficulty and in all cases the platinum and palladium contents agreed well with the corresponding standards.

It was however found that the spectra of all the treated samples showed calcium, magnesium and iron lines. These impurities were found to have been introduced from the filter papers used and in later work this trouble was avoided by the use of a better paper.

TABLE 1

DETERMINATION OF PLATINUM AND PALLADIUM IN REFINERY ATMOSPHERE

| Sample No. | Date | Time | Rate of sampling litres per minute | Vol. of sample cubic metres | Position of sampling and work being carried out | P.M. content of filter pad, mgm. | | P.M. content of atmosphere, μg per cubic metre | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pt | Pd | Pt | Pd |
| 1 | 10.8.44 | 8.15–3.15 (7 hrs.) | 70 | 29·4 | Aqua regia treatment of crude platinum metal concentrate. | 0·063 | 0·019 | 2·1 | 0·6 |
| 2 | 14.8.44 | 8.15–1.15 (5 hrs.) 1.15–4.45 (3½ hrs.) | 70 | 35·7 | Precipitation and filtration of impure $(NH_4)_2PtCl_6$. | 0·12 | 0·079 | 3·4 | 2·2 |
| 3 | 17.8.44 | 8.15–3.30 (7¼ hrs.) | 70 | 30·45 | Dissolving impure platinum sponge in aqua regia. | 0·11 | 0·16 | 3·6 | 5·3 |
| 4 | 11.8.44 | 8.15–3.15 (7 hrs.) | 70 | 29·4 | Precipitation and filtration of pure $(NH_4)_2PtCl_6$. | 0·046 | 0·008 | 1·6 | 0·3 |
| 5 | 22.8.44 | 1.00–4.30 (3½ hrs.) | 70 | 14·70 | Discharging dry $(NH_4)_2PtCl_6$ from drying ovens. | >1·0 | 0·006 | >68·0 | 0·4 |
| 6 | 24.8.44 | 8.15–10.45 (2½ hrs.) 10.45–3.45 (5 hrs.) | 70 | 31·50 | Hand crushing and packing dry $(NH_4)_2PtCl_6$ and $Pd(NH_3)_2Cl_2$ in ashless filter paper. | 0·26 | 1·0 | 8·3 | 32·0 |
| 7 | 15.8.44 | 8.15–2.15 (6 hrs.) | 70 | 25·2 | Precipitation and filtration of impure $Pd(NH_3)_2Cl_2$. | 0·050 | 0·051 | 2·0 | 2·0 |
| 8 | 21·8·44 | 8·15–4·30 (8¼ hrs.) | 70 | 34·65 | Purification of rhodium. | 0·033 | 0·011 | 0·9 | 0·3 |
| 9 | 16.8.44 | 8.15–11.15 (3 hrs.) 11.15–4.45 (5½ hrs.) | 70 | 35·7 | Recovery of small amounts of precious metals from solutions by zinc reduction. | 0·11 | 0·065 | 3·1 | 1·8 |
| 10 | 22.8.44 | 8·15–1.00 (4¾ hrs.) | 70 | 19·95 | Discharging residues from drying ovens. | 0·081 | 0·10 | 4·1 | 5·0 |

Method (*c*) was selected as the most convenient for further work. In view of the slight enhancement of the impurity lines noticed in the spectra of the beads which had been submitted to chemical treatment, it was decided to submit the wire standards to a similar treatment to that employed in the actual tests.

**(4) Application of the Method to the Determination of Platinum and Palladium in the Refinery Wet Process Atmosphere**

Since it was clear that a smelt and cupellation would be necessary, filter pads were impregnated with known amounts of platinum and palladium and put through the furnace operations. The beads obtained were treated by method (*c*) described above. In all cases good agreement was obtained with the corresponding standards.

The esparto grass filter pads carrying the platinum and palladium from the refinery atmosphere were then treated as follows:

The pad was introduced into a size D annealing cup together with 5 gm. of assay lead foil and was ignited gently in a muffle furnace. When all carbonaceous matter had burnt off, the temperature was raised until the residue was well collected in the molten lead. Twelve gm. of flux were then added and the mixture smelted for 30 minutes and then poured. Composition of flux: 120 gm. litharge, 100 gm. borax, 50 gm. soda ash, 5 gm. carbon. The lead button obtained was cupelled on a No. 3 Mabor cupel together with 100 mgm. of proof silver.

100 mgm. portions of the wire standards were also cupelled with 5 gm. lead.

A blank test was made on the flux and proof silver.

The resulting beads from the atmosphere tests and from the standards were then submitted to the following wet treatment.

The bead was cleaned in a silver crucible with hot hydrofluoric acid and, after rinsing with distilled water, it was immersed in boiling 1 : 1 hydrochloric acid for 15 minutes. The bead was then washed thoroughly with distilled water and dissolved in a minimum of concentrated sulphuric acid. The resulting solution was diluted and washed into a 150-ml. beaker and the volume adjusted to 75 ml., 3 ml. of 1 : 1 sulphuric acid being added. The silver and platinum metals were then precipitated from the boiling solution with hydrogen sulphide. The treatment was continued until the precipitate had coagulated giving a clear supernatant solution. The precipitate was filtered on a single No. 00 Swedish 7-cm. paper and washed with hot distilled water, dried and ignited carefully to metal in air.

The silver sponge samples were then examined spectrographically under the following conditions:

*Spectrograph.* Hilger medium quartz (type E.3).
*Spectrograph Slit Width.* 0·015 mm.
*Irradiation of Spectrograph Slit.* The arc discharge is focussed on the prism face by means of a spherical lens (F.1026).
*Arc Excitation.* The arc operates on a 200-volt D.C. circuit.
*Electrodes.* The upper electrode consists of a rod (10 mm. dia.) of Hilger's spectroscopically pure graphite, sharpened to a point. The lower electrode consists of a similar rod of graphite having a shallow cavity formed in the top, 4 mm. in depth. The sample is placed in the cavity and forms the anode.
*Arc Length.* 4 mm.
*Current.* 2 amperes.
*Exposure.* 2 minutes.
No preliminary settling down period is allowed. The slit shutter is opened before the arc is struck so that the melting period of the sample forms part of the exposure.
*Photographic Plate.* Ilford Ordinary.
*Development.* 4 minutes in standard M.Q. developer at 68° F. (20° C.).

Duplicate samples were prepared from each standard and arced, and the spectra of the other samples from the atmosphere tests were obtained on the same plate under identical conditions.

Density measurements were then carried out on a Hilger non-recording microphotometer, using the lines Pt 3064·7A and Pd 3404·6A.

From the measurements relating to the standards, curves were plotted, and by using these curves, the platinum and palladium contents of the samples under test were deduced. Owing to the lack of suitable internal standard lines in the silver spectrum, the 'log ratio' method of plotting cannot be used. Hence in this work the microphotometer readings were plotted directly against 'log concentration.'

Since the weight of silver added to each test was 100 mgm. the percentage figure obtained represents the actual weight of platinum or palladium in mgm. Thus the atmosphere content of these metals in gamma ($10^{-6}$ gm.) per cubic metre is easily calculated.

Table I shows the results obtained for a series of tests on the refinery atmosphere in various positions in the Wet Process Building. All samples were taken at approximately head level.

**Summary**

An estimation was required of the platinum and palladium content of the atmosphere in the vicinity of various operations connected with the refining of platinum metals. Sampling was carried out over periods of several hours corresponding with the time required for completion of the various reactions. The atmosphere was drawn through a particulate filter designed by Hunter and his colleagues.

Estimation of the platinum and palladium collected on the filter was made by igniting the filter and smelting the residue with litharge, charcoal and flux with the addition of a known amount of proof silver, and cupelling the lead button obtained.

By this means the platinum and palladium were collected in a silver bead which was examined spectrographically and compared with synthetic standards.

The content of platinum and palladium in the atmosphere in the neighbourhood of the majority of refining operations was found to be less than 5μg/per cubic metre, due to the provision of local exhaust ventilation. In the handling of dry salts much higher concentrations of platinum and palladium were found in the atmosphere, the highest figure being in the order of 70μg/per cubic metre.

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# THERAPEUTIC USE OF SODIUM CHLORIDE IN INDUSTRY

BY

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Many thousands of industrial workers are subjected to heat by reason of their occupation; for example, non-ferrous metal casters, forge hammer workers (stampers), iron and steel foundry workers, furnacemen and stokers, glass-blowers, heat-treatment operators, lime-kiln workers, shake-house workers and miners. But a much greater number of workers can have their comfort and efficiency temporarily interfered with not because they work on hot processes but because of sweating in hot weather and heat waves, more particularly in those factories where ventilation is poor, or where it may be inadequate because of black-out conditions. Sweat contains sodium chloride in varying amounts, and under ordinary circumstances its loss through this secretion is not significant. But under conditions which cause profuse sweating the unregulated loss of salt in the large amount of water given off as sweat may seriously deplete the supply in the body. The use of sodium chloride in the prevention of discomfort, ill-health and absenteeism due to excessive heat during the summer months is therefore a matter of importance, in the same way that its administration is known to be specific in the prevention of heat cramps and collapse associated with hot processes.

### Body Heat Regulation

According to Howell (1940) the nervous mechanisms which are immediately concerned with heat loss or heat production do not act independently but are co-ordinated with reference to changing conditions so as to maintain a constant body temperature.

Heat is regularly lost from the human body under normal conditions in a number of ways as follows:

1. Through the urine, faeces, saliva, which are at the temperature of the body when voided.
2. Through the expired air, which is warmer than the inspired air and is nearly saturated with water vapour. The vaporization of water requires heat which is taken from the body supply.
3. By evaporation of water from the skin.
4. By radiation of heat from the skin.
5. By convection or conduction, that is by heating the air in contact with the skin.

### Loss of Heat by Sweating in Relation to Working Conditions

Among industrial workers the relative importance of these methods of heat loss will vary with conditions at the place of work. For example, high external temperatures will tend to diminish the loss from radiation, while increasing that from evaporation owing to the greater production and more rapid evaporation of sweat. It has been estimated by Dubois and Hardy, reported by Howell (1940), that under experimental conditions in the laboratory with external temperatures of 70°–80° F., loss by radiation constitutes 60–65 per cent. of the total, and the loss by evaporation about 20–30 per cent. But at temperatures of 90°–95° F. radiation and convection drop out and heat loss is affected only through vaporization. On heat-producing processes and in hot weather excessive sweating at work is common, the degree varying with the occupation and its physical requirements and with the individual. Sedentary workers rarely begin to sweat at temperatures below 88° F., but where heavy physical effort is required sweating begins at lower temperatures. Where temperatures of 80° F. occur, rising as they may do to 90° and even 100°, or more, sweating becomes one of the main ways by which the individual loses heat. Drinker (1936) points out that with external temperatures of 95°–120° F. the amount of sweat produced at ordinary work may be as high as 7·5 litres per day. With a chloride concentration in the sweat of, say, 0·3 per cent. this would mean a loss of 22·5 g. of salt. Since the average normal excretion of salt in the urine is about 12 g. in 24 hours, the degree to which work in heat may deplete body chlorides is clear.

The relation of humidity * is important. If the air is already saturated, sweat is not evaporated and runs off the body with little effect on heat loss. According to Baetjer (1943) at high temperatures a low relative humidity is therefore essential for heat loss, but high humidity greatly increases the harmful effects of heat. There is therefore a vital relationship between the incidence of symptoms and ventilation.

Air movement if adequate does much to create comfort at work. It increases heat loss by exchanging the warm moist layer in contact with the skin with cooler drier air, but if the air temperature is higher than the body temperature and the air is saturated, air movement is of no value in increasing heat loss.

### Chloride Intake

It is generally accepted that the sodium chloride intake should normally be a minimum of 3–4 g. per day (Howell, 1940). With ordinary diets the intake may range between 10 and 20 g. per day, most of it in seasoning, but its reduction to 5 g. or even 1 or 2 g. is said to cause no disturbance (Sollman, 1939). Sodium chloride constitutes the greater part of the electrolytes of the tissues and fluids of vertebrates, and its ions are essential for the maintenance of life. These ions are constantly replenished because of the instinctive use of salt in food. According to Sollman the entire body contains about 0·17 per cent. sodium chloride; of this about one-third is in the skin, the remainder chiefly in the blood, muscles, bones and intestines.

### Chemical Composition of Sweat

The exact chemical composition of the sweat is difficult to determine because it is so frequently mixed with sebaceous secretion. The reaction is usually acid, the *p*H averaging 5·65. The chief salt is sodium chloride in a concentration of 0·5–0·6 per cent. Moss (1923)

* The relative humidity of the air is the amount of water vapour present in the air at any given time expressed as a percentage of the maximum amount which the air could hold at the same temperature and pressure.

states that the chlorides are 60 per cent. sodium, 40 per cent. potassium. Although the amount of chloride in the sweat is in general less than in the blood, it would seem that its excretion by the sweat is unregulated, in the sense that there is no control threshold value such as exists in the case of urine (Howell, 1940). Normally chlorides are excreted mainly by the urine and only a small part by the faeces and skin, but rises in temperature to 80° and 90° F. greatly increase the loss by the skin until it becomes the main medium of chloride excretion.

### Clinical Effects of Excessive Heat

There comes a stage when loss of heat produces in certain groups of workers—particularly those over 50 years of age—clinical signs and symptoms by way of warning such as sweat, thirst, change in taste, headache and fatigue. If the loss is maintained by continued sweating the sense of fatigue becomes greater, vomiting may start, the body temperature rises, cramps of the legs and abdomen develop suddenly and increase in severity, and eventually the man will collapse. This syndrome has been observed during the past 12 years in some 50 cases among non-ferrous metal casters, stampers and forge workers, iron and steel foundry workers, and furnacemen and stokers, especially in hot weather. A simple clinical classification would include three distinct types of ' heat disease ' in industry in this country: (1) heat fatigue; (2) heat cramp; (3) heat collapse. These correspond closely to the classification of Heilman and Montgomery (1936), Johnstone (1942), Baetjer (1943) and other observers. Heat fatigue and heat cramp occur most commonly in occupations where preventive measures are not taken; they can be clearly differentiated, although cramps are frequently accompanied by fatigue or exhaustion.

(1) *Heat Fatigue.* This occurs invariably in the summer months on the rare occasions when the weather is really hot. Workers on processes where heat is given off are more liable to be affected. Increase of atmosphere humidity and diminished air movement in the factory are important causal factors. The condition is commonly found among girls. In hot weather girls frequently complain as groups rather than as individuals, so there is also a potential psychological factor in causation.

> On a hot day in the summer of 1943 four girls engaged in the manufacture of scientific glass, but not working near to each other, went to the factory ambulance room suffering from heat fatigue. In an hour the whole shop of some 30 girls became ' affected ' in what might almost be termed epidemic form. While the four original cases conformed to the clinical syndrome, the majority of the remainder had symptoms so variable that it was difficult to include them in any known physical classification. It appears therefore that they suffered from a ' group neurosis '—not an uncommon entity in industry, and one closely related to the phenomena of unrest in groups of workers. Amongst remedies suggested were better ventilation by increasing air movement; shortening hours of work temporarily; and regular issue of saline drinks (*v.i.*). There has been no recurrence since that time.

The clinical features of heat fatigue are: sweating (this is usually early), thirst, mild headache and a developing fatigue. The patient becomes irritable, girls may cry easily or show other signs of a mild emotional state. In a number of cases the temperature is slightly raised, but the pulse rate is normal. On examination no specific physical signs can be observed.

(2) *Heat Cramp.* The clinical picture of this entity in industry is well known and has recently been described by Johnstone (1942) and Baetjer (1943). Symptoms include all those found in heat fatigue, plus the specific feature of cramp which may occur in the legs but more commonly in the abdominal muscles. One further important diagnostic point is the type of occupation in which the man was at the time of onset.

(3) *Heat Collapse.* This is not common in industry in this country. Only two cases have been observed. Both were elderly men working as stokers in a confined space where ventilation was inadequate, and during a hot summer. In each case the body temperature was over 103° F. The primary diagnostic point was the occupation of the men.

### Administration of Sodium Chloride

*As a Preventive Measure.* It has been shown that profuse sweating is accompanied by salt depletion in the body and the prevention of heat exhaustion consists mainly in the ingestion of sufficient salt and replacement of the fluid loss. There is no evidence that glucose should also be used (Sievers, 1943; Pitts *et al.*, 1944), and Pitts and his colleagues were unable to detect any advantage from administering ascorbic acid, thyamine hydrochloride, riboflavin, or brewer's yeast. The classical work of Haldane (1916, 1929) and Moss (1923, 1924) in connexion with the mining industry, as well as the later accounts of Talbott and others (1937), clearly show the value of salt in preventing fatigue and collapse among hot process workers.*

A main difficulty in finding a suitable preparation was that of taste, and many attempts were made before finally deciding on one both palatable and physiologically correct. According to Dill and others (1936) steel companies in the U.S.A. find that 0·1 per cent. of solution of sodium chloride cooled to 46° F. is agreeable to their workers. A series of experiments with different types of salt drinks in different concentrations was therefore carried out in a large group of foundry workers. It was found that salt with lemon or other flavouring, or salt and oatmeal in water, was not always palatable, and that the giving of pure sodium chloride tablets was frequently associated with nausea unless large amounts of water were given as well. Ordinary water in excess did little to help; it can be actually harmful as it increases water and chloride loss. For the same

* Recent experiments by Pitts and his colleagues (1944) show that the best performance of fully acclimatized young men on a good daily diet, performing intermittent hard work in the heat, is achieved by replacing hour by hour the water lost in sweat. Any less amount of water leads to inefficiency and eventually to exhaustion. Replacement of the salt lost in the sweat hour by hour had no demonstrable advantage; the authors point out, however, that all these men had adequate salt in their diet. They also emphasize that, normally, men at work never voluntarily drink as much water as they sweat, and that there is always the chance of the diet being deficient in salt. "Under such circumstances," they conclude, "it is highly desirable to ensure adequate intake at least of salt, by means of salted drinking water or tablets."

reason large amounts of beer, still frequently taken by foundry workers and metal casters, is a measure to be condemned; it has been stated (Baetjer, 1943) that more heat cases can be expected among workmen who are addicted to excessive consumption of alcoholic drinks.

It was finally decided that a tablet with the following ingredients was the most palatable:

| | |
|---|---|
| Sodium Chloride | gr. 5 * |
| Potassium Citrate | gr. ½ |
| Acid Sodium Phosphate | gr. ½ |
| Sodium Bicarbonate, Citric Acid, Tartaric Acid, Saccharin, Oil of lemon | q.s. |

The different ingredients, other than sodium chloride, have purely a dispensing value in the manufacturing process. Each of these tablets when dissolved in ½ pint of water makes a pleasant drink with an approximate concentration of 0·1 per cent. sodium chloride.† In the great majority of workers on hot processes one to three pints of this mixture per shift will entirely prevent the onset of unpleasant symptoms; if symptoms do occur this frequently removes them in the most dramatic way. Some workers like to suck the tablets in the mouth, but dilution in water is always necessary because of the need for fluid replacement.‡

In the prevention of heat symptoms the basic importance of improving working conditions must be emphasized, and it should be remembered that the physical fitness of the worker and the type of clothing he wears are additional factors in determining the onset of symptoms. Saline drinks are only a palliative and where possible the cause of excessive heat at work should be removed. One of the difficulties during war-time has been the provision of adequate ventilation because of black-out regulations. In the U.S.S.R. Starkov and Jikesh (1935) studied the reactions of a group of workers in hot industries and the first remedy they suggest is improvement of working conditions; this included the introduction of water-screens and forced ventilation, provision of adequate rest periods, training of new workers, and pre-engagement medical examinations.

*Treatment.* Talbott and others (1937) advise at least 2 litres of normal saline solution intravenously in cases of heat collapse. When swallowing is impossible or difficult intravenous injection must be the method of choice, but not in the industrial medical departments in this country; such cases must become the responsibility of the hospital physician. In hot climates, and especially in the tropics, either on land or at sea, adequate provision has to be made at the place of work for immediate therapy if life is to be saved.

Other therapeutic measures used in the U.S.A. have been adrenaline, calcium gluconate, glucose (10–50 per cent.), nitrites and calcium chloride (10 per cent.), sodium bicarbonate (3 per cent.), but in the experience of Drinker (1936) and others no one of these has been successful.

Heat cramps of the most severe type are rare, but treatment in the factory should consist of the administration of 0·4 per cent. saline by the mouth (4 tablets in ½ pint of water). These cases must always be referred direct to hospital in the same way as a serious injury, and be given similar general treatment.

Mild heat cramps are treated by Talbott by the ingestion of 2–3 litres of 0·5 per cent. salt solution, and in his view such cases need not be sent to hospital. Moderate and mild cases, and cases of heat fatigue, rapidly improve with ½–2 pints of the 0·4 per cent. mixture prepared for the severe cases. An hour's rest in the factory ambulance room usually cures the condition, but even in cases that are mild it may be advisable to prohibit work for the rest of the shift.

* While tablets containing 7½ or 10 grains NaCl are equally palatable there are manufacturing difficulties where the amount is over 5 grains. In concentrations over 0·2 per cent. (10 grains/half-pint) salt is noticable in the mixture, which then becomes unpalatable.

† These tablets are used to-day at the rate of nearly 1½ millions annually.

‡ It has been suggested by Pether (1944), after observation of this problem in the Middle East with the R.A.M.C., that potassium chloride should be added to the salt mixture; and the saline drink described by Oswald (1925), and used for stokers at a large gas works, contained 2 parts of potassium chloride for every 3 parts of sodium chloride, i.e. the proportion found by Moss (1923) in the sweat. Further work on this point may therefore be necessary.


### Summary

Excessive sweat is accompanied by abnormal loss of sodium chloride through the skin. Fluid replacement is necessary and should include sufficient sodium chloride, otherwise the individual will suffer from fatigue, cramp, or collapse.

In industry symptoms due to heat occur mainly among elderly workers on hot processes where extensive physical effort is required.

In heat waves any worker can be affected so the need is stressed for adequate ventilation of departments and shops where hot processes are worked, and for better general factory ventilation, with special reference to the promotion of air movement and humidity control.

A suitable preparation of sodium chloride in tablet form is described. One tablet contains 0·3 g. (5 grains) of sodium chloride, and when dissolved in ½ pint of water makes a palatable drink. After extensive trial this has proved satisfactory in the prevention of fatigue and other symptoms due to excessive heat.


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## HEALTH IN THE SHIPPING INDUSTRY

Sea transport is a vital British industry and the health of those who work in it is of high importance. The number of men employed in the shipping industry is comparatively small considering the immense work it accomplishes and the fact that it comprises some 30 per cent. of the world's gross tonnage.[1] In June, 1942, the number of British merchant seamen was estimated at 120,000—equal to about eight army divisions. This group included 4530 masters, 12,950 deck officers, 19,800 engineers, 35,400 deck ratings, 29,000 engineer ratings and 17,400 stewards. Even if we add to this some 45,000 Indians (or lascars), over 6000 Chinese and a number of Arabs, the total personnel is less than 200,000.[2] Nevertheless the hazards in this industry are great: the risk of collision, of grounding on rocky coasts in heavy seas, fire and explosion. There are also hazards to health which are less dramatic perhaps but equally significant. The mortality rates of merchant seamen between the ages of 20 and 64 are approximately double the standard rate for the same age group, the death rate from tuberculosis among seamen being four times greater than among the general population.[3] It has also been shown that 17 per cent. of all deaths occurring within a year of leaving the sea are due to tuberculosis.[4] More recently it has been noticed that merchant seamen arrive for treatment in a more advanced stage of the disease than do the general public,[5] and over-crowding in quarters at sea is considered the chief cause of this. Venereal disease is responsible for approximately 10 per cent. of illness among merchant seamen.[6] The welfare of the seaman in port is a matter for concern, and it is of interest to see that a Government report on this has just been published.[7] It is estimated that throughout his working life a seaman spends on an average two months in twelve ashore, and during this time he has ample opportunity for contracting disease: the incidence of venereal disease is higher in the ports than anywhere else. In addition to welfare, measures must be taken to conserve health. If some form of 'pool' system is to remain—and it has much to commend it on sociological grounds —then it could well be a medium for the development of medical supervision of seamen ashore. Because the need had become so obvious the docks medical service at one large port already caters for seamen, as apart from dockers, by private arrangement and entirely in a voluntary capacity. Here is an interesting link-up between two branches of industrial medicine.

The contribution by Dr. Jameson Carr to this subject in this number of the JOURNAL is opportune. Some of the conclusions arrived at need immediate attention: for example, the urgent health requirements of the smaller vessels, particularly freighters, where there is no doctor and sick quarters are inadequate; the need for improving crews' quarters generally; and the institution of pre-employment and follow-up medical examinations throughout the industry. Pressure must be brought to bear on the appropriate companies to improve matters. The difficulty of deciding what authority to approach is an example of the need for integration of our national health services. The Ministry of War Transport is, as its name suggests, a temporary body; medical services at the Ministry of Labour are mainly concerned with factories; and the Board of Trade is said to be conservative of existing interests and unlikely to suggest or impose reforms on unwilling companies. As the port medical officer has much to do with ships, their passengers, and their crews, it might be reasonable for his parent body, the Ministry of Health, to play a larger part in preserving the health of merchant seamen than it has in the past. If individual companies, represented perhaps by the Shipping Federation Limited, and trade unions such as the National Union of Seamen and the Navigators' and Engineer Officers' Union, got together to discuss this matter with representatives of the medical profession some good would surely result. It is interesting to note that the Royal College of Physicians of London propose to issue a report on this subject in the near future.[8] It is hoped that they will marshal the available evidence in favour of better health supervision of this branch of industry in such a manner that the country will be convinced of the need for reform. It may be that one way of doing this would be to appoint doctors to survey the position on the spot. Health surveys in different industries could well constitute the next advance in research method, for matters such as these present a live challenge to modern medicine.

The trade unions have already outlined their views in the International Seafarers' Charter.[9] This has been adopted in principle by the International Commission — the joint International Labour Office committee of seamen's and shipowners' organizations—and the Governing Body of the I.L.O., and will serve as a basis for discussion at an International Maritime Conference to be held in October, 1945, to which twenty countries are to be invited. It is hoped that doctors with experience of maritime medicine will be among the 'necessary

[1] *Whitaker's Almanack*, London, 1945; p. 199.
[2] *Merchantmen at War*, 1944. H.M.S.O. Lond.; p. 14.
[3] Registrar-General's Decennial Supplt. 1931. Pt. II. Occupational Mortality (1938). H.M.S.O.
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[7] *Seamen's Welfare in Ports*, 1945. Report of a Committee appointed by the Minister of Labour and the Minister of War Transport in 1943. H.M.S.O., Lond.
[8] Second Interim Report of Social and Preventive Medicine Committee (R.C.P. London): Industrial Medicine. (1945); p. 13.
[9] *The Seaman*, Nov. 1944; *Labour Research*, March, 1945; p .38.

technical advisers' who will also attend the Conference. The Charter includes important recommendations on living conditions, hygiene and medical services. It points out that conditions in British ships compare unfavourably with those of the U.S.A. and a number of continental countries; and that in 1938 the death rate for tuberculosis among seamen was 47 per cent. above the national average and the death rate for duodenal ulcer 32 per cent. above. Wood for bunks, furniture and floors should be replaced by metal or plastic materials to safeguard against vermin. Beds and bedding, including sheets, should be supplied by the shipowners. Adequate heating and ventilation should be provided by an air-conditioning system. There is an urgent need for good lavatory accommodation, a ship's laundry, and a drying room for the men's use. All ranks should pass a medical examination before going to sea. Finally, the Charter recommends that there should be better food and feeding arrangements; cooks should be properly trained; and galleys in all new ships should be provided with refrigerators and other modern kitchen equipment.

The doctor in close daily contact with the merchant seamen—the worker in this industry—is the ship surgeon. He is an industrial medical officer no less than his colleague in the factory. The number of permanent ship surgeons in peacetime is estimated at about 300. In addition perhaps 1000 ships employ temporary surgeons who sail for one or two voyages. British ship surgeons, unlike those in certain other countries, are not required to attend courses in maritime hygiene. Whether such courses should be compulsory or not is beside the point: here is an immediate field for post-graduate training. Courses in this branch of industrial medicine must include the general principles of ship construction, hygiene of crews' quarters, ventilation, heating and lighting; dietetics and food storage; knowledge of diseases such as cholera, plague, yellow fever, typhus and smallpox, and the problems of disinfection and disinfestation; modern treatment of medical and surgical emergencies; and the various legal requirements which concern the shipping industry. Above all the ship surgeon must be trained in the principles of preventive medicine, and he must be selected as much for his personal character and outlook in this direction as for his technical skill. Properly organized courses of instruction should be started at the Universities of London, Liverpool and Glasgow, at the earliest opportunity; these should be the responsibility of a University Department of Industrial Medicine. Thus as a profession we could make a contribution now to a national problem of much urgency.

## TRINITROTOLUENE

TNT is the symmetrical trinitro derivative of toluene; it was first made in the laboratory by the German chemist Hepp in 1860, and was first put to use as an explosive by the German military authorities in 1902. Present-day explosives fall broadly into three divisions: initiators, of which the principal ones are mercury fulminate and lead azide; intermediates, for which tetryl is almost exclusively used; and the main explosive charge for which, until recently, a TNT mixture was always used. In peace-time TNT is used in blasting operations.

At first TNT was thought to be a non-toxic substance and Prosser White [1] showed that dinitrobenzene was more toxic to animals than TNT. Koelsch [2] stated that pure, recrystallized TNT does not possess the toxic properties observed with the crude material. In his view serious toxic effects from fairly pure material are exceptional, and the degree of contamination is the decisive factor in its toxicological action. Yet in the last war the first fatal case in England occurred as early as February 1915. It soon became evident that the substance caused five definite clinical syndromes: dermatitis, methaemoglobinaemia, gastritis, toxic jaundice, and aplastic anaemia. The clinical picture has recently been well described by von Oettingen.[3] These diseases affected so many workers that on January 1, 1916, toxic jaundice was made a notifiable disease, and as a result 181 cases with 52 deaths were notified in 1916, 189 cases with 44 deaths in 1917, while the greater knowledge of the danger and the introduction of preventive measures reduced the notifications in 1918 to 34 cases with 10 deaths. In the same period there were 15 cases of aplastic anaemia, all of which were fatal. The situation in 1916 was serious, and the Medical Research Council initiated much research as a result of which Moore [4] was able to show that the usual route of absorption of TNT was through the skin, but von Oettingen and his co-workers [5] have disproved this conception and shown that absorption through the skin is insignificant compared to inhalation or ingestion from the alimentary tract. Webster [6] devised a valuable chemical test for demonstrating the presence of TNT derivatives in the urine, and this test was improved by Ingham,[7] making it sensitive to 1 part in 10,000. Von Oettingen developed spectrophotometric methods for the determination of 2, 6 dinitro-4-aminotoluene and other derivatives of TNT in biological materials. Panton [8] showed that toxic jaundice and anaemia appeared to be separate pathological states. Anaemia might occur without jaundice and only 17 per cent. of the jaundiced patients became anaemic, while Turnbull [9] found at necropsy a fatty marrow throughout the long bones in two fatal cases of aplastic anaemia, the liver being rusty brown from an excess of iron pigment. Minot [10] suggested that TNT caused both increased destruction and increased formation of red blood

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1 *Lancet*, 1901, **2**, 582, 709.
2 *Zbl. Gewerbehyg.*, 1918, **6**, 15, 26, 53, 66, 88.
3 *U.S. Publ. Hlth. Bull.* No. **271**, 1941.
4 Spec. Rept. Ser. Med. Res. Com. Lond., 1917, No. 11.
5 *U.S. Publ. Hlth. Bull.* No. 285, 1944.
6 *Lancet*, 1916, **2**, 1029; Spec. Rept. Ser. Med. Res. Com. Lond., 1921, No. 58.
7 *Lancet*, 1941, **2**, 554.
8 *Ibid.*, 1916, **2**, 77.
9 *Proc. roy. Soc. Med.*, 1917, **10**, 47.
10 *J. industr. Hyg.*, 1919, **1**, 301

cells. Voegtlin, Hooper and Johnson [1] and Teisinger [2] noted a marked leucocytosis in about 20 per cent. of the workers examined, but Teisinger found leucopenia in 17 out of 54 workers, whereas Voegtlin and his colleagues noted it in only 4 per cent. of workers. In the field of experimental pathology Voegtlin and his co-workers observed that guinea-pigs and rabbits appear to be less sensitive to TNT than cats and dogs.

During the present war only 99 cases of toxic jaundice, of which 23 were fatal, had been notified up to the end of 1943, while 9 cases of toxic anaemia had occurred before February, 1942. It seems certain that this smaller incidence is not entirely due to preventive measures. The unsymmetrical isomers of TNT are more toxic than the symmetrical material, and the improved manufacturing methods of to-day produce α-TNT practically free from the isomers, whereas in the last war these were present in considerable quantity. Our relative freedom from serious trouble in this war may be due to this fact, though it is possible that diet may also play a part. Himsworth and Glynn [3] showed that rats treated with α-TNT and on a high fat diet developed necrosis of the liver, while in animals taking a high carbohydrate or a high protein diet the ill-effects were slight or absent. Himsworth [4] has suggested that TNT combines with amino-acids forming a combination which is not metabolized by the body; in this way a state of conditioned amino-acid deficiency may arise and in such a state liver damage may occur. Von Oettingen was unable to produce injury to the liver in experimental animals. Different animals metabolize TNT through different chemical derivatives, and he suggests that some of these amino derivatives produced in the organism may have a more injurious effect on the liver than others. In this case, the observation of toxic hepatitis in TNT workers might be explained on the basis of a greater production of these metabolites in the body. It must be remembered, however, that in this war there has been an organized medical service in Royal Ordnance Factories which, in collaboration with the Factory Department, has certainly contributed to the comparatively low incidence of TNT poisoning. Since there has been little trouble in filling factories, however, little work has been done in England on TNT during the present war, but Noro [5] made observations on TNT workers in Finland during the first Russo-Finnish war. She showed that reticulocytosis was not very great during the period of actual exposure, but that it became more evident when the worker left contact with TNT, suggesting that reticulocytosis is a reparative phenomenon which is to some extent inhibited by TNT.

In this issue Alice Stewart, Witts, Higgins and O'Brien report their findings in a number of students who had volunteered to fill shells with TNT during the vacation. Their chief subjective complaints were nausea with variable loss of appetite, diffuse abdominal pain, vomiting and diarrhoea, fatigue, and nasal and throat irritation. The symptoms came on after an initial period when there was an increased sense of well-being, accompanied by a voracious appetite. There was evidence of haemolysis in over 85 per cent. of the students, with a fall in haemoglobin, red cell and haematocrit readings. There was also an increase in reticulocytes, bilirubinaemia with urobilinuria and a marked erythroblastic response in the marrow. The reticulocyte response was not maximal until a few days after exposure had ceased. This suggests that TNT, in addition to a destructive action on the circulating red cells, also affects the bone marrow. Cases of serious TNT poisoning have also been reported by Evans,[6] Hilton and Swanston,[7] Lane,[8] and Davie.[9] The last named described a necropsy on a woman TNT worker who showed acute toxic purpura. As a contrast to Turnbull's case in the last war her marrow was markedly hyperplastic, the femur contained red marrow throughout the upper three-quarters of its length, and microscopically all the elements of the marrow were represented. Rimington and Goldblatt [10] showed that workers exposed to aromatic nitro and amido compounds had their urinary coproporphyrin excretion increased up to 50 times and there is good evidence that it is also increased in TNT workers. Channon, Mills and Williams [11] have investigated the metabolism of TNT and have shown that hydroxylamine, which is formed in this process, is a powerful producer of methaemoglobin in vitro. In describing the TNT health hazard Roberts [12] gives a schedule for its control. There should be selection of workers and a record kept of the physical condition on entry: no person under 19, no woman weighing under 105 lb., no one with sweaty hands or a history of jaundice or yellow sclerotics, should be allowed to do the work. Sick absence should be carefully recorded, and for the first five months absences certified as anaemia, gastritis, or general debility, should be the subject of investigation by the factory medical officer. In addition Roberts advocates periodic examination for signs of TNT absorption, a record of TNT stains on the body or clothing, and arrangements for foremen and supervisors to draw attention to workers looking off colour or complaining of fatigue or breathlessness; scrupulous attention must be paid to the provision of protective clothing, personal cleanliness, and to control of dust by adequate ventilation.

1 *Publ. Hlth. Rep.*, 1919, **34**, 1307; *Hyg. Lab. Bull.*, 1920, **126**; *J. industr. Hyg.*, 1921, **3**, 239, 280.
2 *Arch. Gewerbehyg.*, 1933, **4**, 491.
3 *Clin. Sci.*, 1942, **4**, 421.
4 *Proc. roy. Soc. Med.*, 1945, **36**, 101.
5 *Acta med. scand.*, 1941, Supp. 120.
6 *Lancet*, 1941, **2**, 552.
7 *Brit. med. J.*, 1941, **2**, 509.
8 *Proc. roy. Soc. Med.*, 1942, **35**, 556.
9 *Ibid.*, 1942, **35**, 558.
10 *Lancet*, 1940, **1**, 73.
11 *Biochem. J.*, 1944, **38**, 70.
12 *Brit. med. J.*, 1941, **2**, 647.

# SOCIAL MEDICINE AS A DISCIPLINE *

BY

JOHN A. RYLE

*Oxford*

In a highly industrialized country like ours industrial medicine must clearly be accepted as a large and very important branch of social medicine as a whole. Both are concerned with the study and the service of community health and sickness, are likely to employ common methods of socio-medical inquiry and to require similar or identical departments for training and research. If interest in, and the provisions for, industrial medicine have hitherto been slow of growth there is no doubt that their rate of growth will now be accelerated, and that workers in this field will make new and valuable additions to method and to the other foundations of knowledge upon which the social medicine of the future must build its disciplines.

In the short period since I went to Oxford I have repeatedly been asked for definitions of social medicine. None that I have seen or attempted have seemed to me entirely satisfactory, for they cannot at once be sufficiently brief, detailed and comprehensive. The subject is too large. We can, however, say that it is concerned with aetiological inquiry in its widest sense. It has already evolved and will continue to evolve methods of study appropriate to its purposes, among which vital statistics and socio-medical surveys—with the gradually improving techniques which they require—will make essential contributions, while neither laboratory nor social experiment will be excluded from its province. Education, research and practice are all of as much interest to it as they are to clinical medicine, from which (like the medical sciences) social medicine is a natural off-spring. It is concerned with the man-environment relationship, using environment in its fullest implication to include both the material and the personal environment. Its interest is with health quite as much as with disease. In a recent paper (*Nature*, 1944, March 25, p. 363) Professor Sargant Florence defined social medicine as ' the study of the variations in human health and efficiency associated with variations in social conditions.' This is an acceptable definition in so far as the research functions of social medicine are concerned, but it gives no indication that the subject has other academic functions in the sphere of undergraduate and post-graduate teaching and manifold functions in the sphere of practice.

As one entrusted with a reorientation of undergraduate teaching and the organization of a new research institute my interest is primarily in social medicine as a discipline. As such it may be properly regarded for, like clinical medicine, it is not a science nor yet, on the other hand, to be considered merely as an art or mode of practice. Without a careful study and development of methods and principles it is even possible that social medicine in its new phase—for the ideas supporting it are by no means new—might be given a false start at a time when its contributions alike to human knowledge and well-being are more than ever in demand. Perhaps I may make my present concepts and approach clearer to you by describing—in illustration of social medicine as a discipline—some of our small beginnings at Oxford. But before doing so it may be helpful briefly to outline the influence on medicine of certain other disciplines which have marked the history of the past century. In the process we shall discover some gaps which have been left in the main structure and the consequent need for a considered integration of all the sciences relating to man, that is to say the biological, the clinical and the social sciences. With this integration social and industrial medicine must be intimately connected. Both the historical retrospect and the illustration from current experience may serve as a preamble to the few suggestions which I shall then put forward bearing upon developments and partnerships in your own sphere of interest.

### *Historical Retrospect*

If we look back upon the evolution of medicine in the past century we can recognize three distinct, if overlapping, disciplinary periods. The first might be described as the period of the ' pathological disciplines,' in which, under the influence of the great physician-pathologists—notably Bright, Addison, Gull, Hodgkin and Wilks in this country—the intimate study of morbid changes and processes in the dead-house came to add finite knowledge to the naturalistic medicine of Hippocrates and Sydenham. Histological, chemical and experimental methods followed, but the whole edifice of pathology was reared upon the foundations of morbid anatomy. This pathological discipline was concerned with disease rather than with man in disease.

The second period was the period of the ' experimental or laboratory disciplines ' and witnessed the evolution of bacteriology and protozoology under the influence of Pasteur, Koch and the great malariologists. A little later came the contributions of the biochemists and nutritional physiologists, whose work is reaping such a rich harvest to-day. These disciplines have all been concerned with the specific causes of disease, for the most part patiently elucidated in the laboratory and with the aid of the laboratory animal, although they were frequently prompted and assisted by experience in the clinic or the field.

The third period, from which we are now just emerging, might be described as the period of the ' technological disciplines.' It has witnessed the invention of innumerable diagnostic instruments and techniques, including those due to radiology, cardiography, chemistry, endoscopy and biopsy. These techniques have assisted

* An address to the Association of Industrial Medical Officers given at the London School of Hygiene and Tropical Medicine, October 16, 1944.

the more accurate recognition and study of the appearances and processes of disease in the living patient. They have provided methods of physiological and pathological study at the bedside. Like the other disciplines they too have been concerned with the study of disease in man rather than man in disease.

These three disciplines have been and will remain invaluable and necessary to progress, but they have all tended to distract attention from the patient as a person and as a member of a family or group or larger society, and from those domestic, occupational, economic and other stresses which so frequently provide the background of disease and disability. They have studied the intimate rather than the ultimate causes of disease. They have, to a considerable extent, been responsible for the over-specialization of thought and action which has marked the medicine of the past half-century, in the course of which the old clinical humanism has suffered a partial eclipse. Important though their influence has been on the teacher and the student and on practice, it has not been always or wholly a beneficent influence. We have lacked during the period of their development an integrating discipline to enable us to see things whole and in their proper relationships to one another.

During the same century in which these disciplines evolved, and prompted by the pioneer influence of men like Chadwick, Simon, Southwood Smith and Farr, there was, of course, a parallel discipline directed towards the study and elimination of the environmental causes of disease. I say ' parallel ' advisedly, for preventive and remedial medicine have never shared their problems as freely as they should have done. Drainage, water supplies, and the detection and isolation of infectious disease and, more slowly, attention to housing and the material conditions in industry were until a relatively recent date the chief concern of public health authorities and the factory inspector. Consideration for the personal, social, economic and nutritional aspects of public health—as for the psychological aspects of individual health—somehow lagged behind. We now recognize that the discipline of public hygiene has been open to the imputation of being, like the other three, impersonal. The intimate man-environment relationship, like the mind-body relationship in clinical medicine, was not sufficiently stressed in the earlier conceptions of industrial and preventive medicine. In the medical schools, as in the service of the community, remedial medicine and public health have been treated in separate compartments. The practitioner for the most part has become remarkably incurious about the causes of disease and their removal; the health officer, too, incurious about the intimate life of the citizens whose health he protects. Health education has been but tentatively fostered. To put the case quite briefly and in another way, disease and its immediate causes have been intimately studied; health and its causes are only just beginning to attract the attention which they should command; the patient as a person (rather than a ' case ') and as a member of a social group has often been neglected.

And so, coming full circle, we discover the need for fresh directives in the shape, firstly, of a better planned social medicine, serving as an integrator and influencing both education and research and, through them prevention and practice; and, secondly, of a better planned clinical and personal medicine, which will keep in better perspective the body-mind-environment relationships of the individual. It is surely significant that both the Goodenough Committee's report and recent memoranda of the Royal College of Physicians should have emphasized the urgent need for developing the teaching of social and of psychological medicine in the undergraduate period. The applications of such teaching to the problems of industry need no emphasis.

### *A Teaching Programme*

Now let me briefly relate how we are hoping to meet this situation at Oxford in the respective fields of education and research. We are first of all trying to ensure that the teaching shall become available throughout the clinical period. Social medicine should not and cannot be regarded as another special study. Its relations with clinical medicine are too obvious; they must be taught together. The course which we gave in the first working year included a series of lectures by myself on the broader scope and aspects of the subject, with special consideration of outstanding diseases such as tuberculosis, the venereal diseases, rheumatic fever and peptic ulcer, each discussed as a social rather than as a clinical problem. A second series of lectures was given by my colleague, Dr. W. T. Russell, on the elements of vital statistics, with consideration of mortality tables and their preparation, of infant and maternal mortality and mortality in relation to occupation and socio-economic class; and on the epidemiology of measles, diphtheria, whooping cough and tuberculosis. In addition we arranged for special lectures or demonstrations on their services or particular problems by Dr. Williams, Medical Officer of Health for the City of Oxford; Dr. England, Tuberculosis Officer for the County of Oxfordshire; and by Miss Rees, head of the Almoner's Department at the Radcliffe Infirmary, on the province and functions of the medical social worker.

Our other main approach to the subject is through the method of the case-conference. These conferences are attended by students in the clinical period and by house-officers and other medical graduates and almoners. A case from the wards or elsewhere is first of all presented clinically by the medical clerk or house-physician. It is next presented from the social point of view by the almoner (as medical social worker), who will have secured the full co-operation of the patient and visited the home or place of work or both and made the necessary inquiries in regard to the domestic and economic situation, to work and wages and any particular difficulties in the material or personal environment. Regarding the conference as a consultation we then endeavour to see what correlations may be established, or at least considered, between the patient's disease and his or her living and working conditions and, with the help of the senior almoner, what can be done on discharge from hospital to ensure an amelioration of conditions or the availability of special forms of help and after-care or re-employment. Not infrequently, as might be expected, and especially in the more chronic types of case, the social history throws quite as much light on the patient's trouble as the detailed investigations in the hospital ward. A diagnosis is achieved in the fuller sense of the word. We have also arranged for field-visits for small groups of students to a factory welfare centre (the works themselves, for security reasons, are not at present accessible) and to public health concerns. Later we hope to provide experience for some of them in the shape of home visits and an introduction to the methods of social history-taking. As between the lectures and other demonstrations we thus provide a preliminary view of social medicine as it touches both the individual and the community. The background of vital statistics I regard as particularly important, for the student in hospital is too little informed about the

incidence and mortality (according to age, class and occupation) of the diseases which he sees.

*The Work of an Institute*

Turning next to the work of the Institute of Social Medicine, it should be mentioned that, in addition to my own staff, the Institute houses at present the Oxford Nutrition Survey and the Bureau of Health and Sickness Records.* The latter comes under my directorship and is equipped with modern punch-card and sorting machinery. Our first field-survey is directed to a study of the health, growth and development and infection-experience of the pre-school child in the City of Oxford and will cover a large sample to be obtained from all social groups. This survey is based on the welfare centres and involves correlated clinical, anthropometric and social studies and a three-monthly follow-up—a paediatric research assistant collaborating with a social worker under the general direction of myself and Dr. Russell. Dr. Dagmar Wilson and I have also been engaged upon a goitre survey in north Oxfordshire on behalf of the Goitre Sub-Committee of the Medical Research Council. Dr. Russell has undertaken an analysis of sickness absenteeism records in a large factory with a view to correlating accidents and the main types of sickness with age, sex, season and particular trades or types of work. We have already a good collaboration with the health departments in the City and County, and with the medical and welfare departments of a factory. We are considering, in a preliminary way, the standardization of a pre-employment health examination.

It is not likely that the Institute will interest itself in specific industrial hazards. We look to Dr. Donald Hunter and his department at the London Hospital and to others for the further activation of interest and research in this important field. It is more than likely, however, that we shall interest ourselves in the prevalent types of illness encountered among factory workers, illness not necessarily confined or directly or wholly due to the particular industry but causing a large sick-wastage in it or in industry as a whole. Peptic ulcer and the chronic rheumatisms might well be studied in a factory community in their possible relationships with age, sex and season and with changing shifts and certain types of physical and mental stress. We have enough on hand to keep us busy for some time to come. You will note that we make no sharp distinction in our minds between industrial and other social problems. Industry, we recognize, provides communities and environments which lend themselves to particular studies, but the worker has his domestic environment too and is a member of the general community. Given good co-operation and understanding social experiments should, however, be more readily devised in a factory than in more scattered populations. Changes in the material environment, hours of labour and amenities can be made and their effects on health and output statistically assessed. Such experiments must eventually prove of value both to the worker and the work.

* Endowed by the Nuffield Provincial Hospitals Trust and serving the Berks, Bucks and Oxfordshire Region.

*Future Developments*

Finally let us consider how the universities may come to play their part elsewhere in the development of this new discipline. Edinburgh and Birmingham are establishing departments of social medicine and it is quite clear that there will be room for other departments or institutes having a university association and envisaging diverse programmes of teaching and research. Some of these will doubtless concern themselves primarily with the problems of industry. The practice of industrial medicine can only benefit from academic collaboration.

How and where could industrial medicine as a discipline within the broader framework of social medicine be best developed? Given the men and women with appropriate training and vision, given the endowments which it would well repay industry itself to provide, it would at least seem reasonable to suggest that a great university city, such as Manchester, might include within its medical faculty a department of social medicine wherein the problems of health in the factory, shop or outdoor trades would be a first consideration; that Liverpool, as a great seaport and university city, might have an institute with a special interest in the problems of maritime hygiene and of sickness hazards and incidence among seamen, both at sea and ashore; or that Cardiff might create an institute which would turn its attention more particularly to the problems of health and disease in mining communities.* In such institutes (which I would rather see associated with a university than specially erected to work in isolation on behalf of a single industry or on a specific problem) there should be opportunities for the post-graduate training of doctors and social workers as well as for statistical and field or other special research. With them the practising industrial medical officer should share his experience and his difficulties. And always there should be the closest possible relationship between the academic department and all those engaged in handling the practical problems of health and disease in nearby working communities. The clinician, the statistician, the nutritional physiologist, the industrial psychologist, the social worker and others will find their place in the academic team. Laboratories for physiological, nutritional and psychological investigation, a library and reference bureau and statistical machinery will be necessary features of such institutes. But social and industrial medicine will always need to pursue their problems in the field, to study the community at risk and so to counteract the old tendency to academic detachment from which medical research and teaching in this and other countries have too long suffered. The framing of disciplines and the integration of clinical, scientific and social studies are tasks of such fundamental importance that we would do well to give them the most careful consideration and to avoid precipitate adventures. These subjects are now much in the public eye. It will fall to your Association, among others, to ensure that they are wisely fostered.

* At the time of delivery of this address the announcement of the Nuffield Foundation's offer of grants totalling £150,000 for the development of teaching and research in industrial medicine at Manchester, Glasgow and Durham had not been made.

# VISUAL STANDARDS IN INDUSTRY *

BY

JOSEPH MINTON

*London*

With the expansion of industrial medical services has come the realization that industry presents many visual problems which have to be faced and eventually solved. So far, although this country has made no unified attempt to deal with the vision of employees, individual firms have done so.

In 1938 the Industrial Welfare Society sent out a questionnaire to its 750 member firms in order to find out whether applicants for employment had to pass eyesight tests and what minimum visual standards were considered necessary. From the replies received from 398 firms, employing about 1,000,000 workers, it was found that most firms do not insist on eyesight tests; and that the many firms who are vision conscious vary in their approach to the problem. Thus while many small firms do not require employees to pass eyesight tests, firms representing the same branch of industry insist on them. A large number of firms, having instituted eyesight tests demand a visual standard of 6/6 or 6/9 in each eye, while other firms are satisfied with 6/12 in each eye.

In this paper an attempt is made to elucidate some of the principles which may guide industrial medical officers in the selection of employees for various jobs in industry. There is no doubt that greater efficiency will be achieved if workers are placed in jobs for which they are best physically fitted. This would eventually be followed by larger output and would in addition ensure the safety of the workers in many branches of industry. But under present conditions of employment a country-wide compulsory medical examination could not be instituted for all workers. Should such an examination be carried out a huge pool of physically unfit would be created whose members would have to be retrained and then placed in suitable employment. This is a big problem which it is hoped will be tackled in the future. A number of private firms have already adopted the principle of compulsory medical examination of new employees and direction of workers into jobs for which they are best physically fitted. This policy, which is ideal if carried out in combination with the training of the physically handicapped, must be put on a sound medical basis.

### *Ophthalmic Work of the Examining Surgeon*

The Factories Act of 1937 provides that juveniles (14–16) should be examined by the Examining Surgeon and an eyesight test carried out. The general examination must be thorough and the Examining Surgeon should be able to refer cases to consultants for special examination. At present he is given no instructions on the visual standards required in the various branches of industry, and in most cases he has no facilities for efficient examination of vision. It is essential that the Examining Surgeon and the industrial medical officer should use a Snellen's test type at 20 feet. Should the vision of the applicant for employment be less than 6/12 in each eye he should be referred to an ophthalmic surgeon. All Medical Boards examining men for war service refer those whose vision is less than 6/12 in each eye to an ophthalmic surgeon for an opinion. The same procedure might well be followed by the Examining Surgeon and the industrial medical officer. The ophthalmic surgeon would then report on the vision of the individual as corrected with glasses. The visual standards laid down by the Army, Navy and Air Force are based on the vision of the individual corrected with glasses. In special jobs in the Navy and for air crews in the Air Force as well as in the case of drivers of public vehicles (trains, buses and trams) high visual standards without glasses are demanded. For workers in industry the use of glasses presents no handicap and the efficiency of the worker is in no way diminished by their use. On the other hand investigations in the various branches of industry have shown that workers whose vision has been satisfactorily corrected with glasses have suffered from fewer symptoms of eyestrain when engaged at work than the workers who have not had an ophthalmic examination. Any reference, therefore, to the vision of an individual should imply the vision corrected if necessary with glasses.

### *Suggested Visual Groups in Industry*

Modern industry is capable of employing men and women with all grades of vision—from grade 1 with the highest vision, to the partially and even totally blind. The standards of vision required in industry need not be rigid and should vary according to the job. For purposes of classification all occupations can be divided into four groups. In the first group are the occupations which require especially good eyesight such as the very close work necessary in the manufacture of silk yarns, silk hose, inspection and manufacture of electric light bulbs and radio valves, watch making, invisible mending and jewel work. In the second group are the occupations which require normal eyesight. In the third group are those occupations suitable for those with weak eyesight such as cookery, soap-making, gardening and bill-posting. In the fourth group are the trades in which blind people are employed; brush-making, basket work, piano tuning, massage and physiotherapy and many others.

The following grades of vision are suggested in allocating applicants for employment, whether juveniles or not, to various occupations.

*Grade* 1 *Vision.* To this group belong all those possessing 6/6 or 6/9 vision in each eye and also those having 6/6 in one eye and not less than 6/36 in the other eye. Individuals in this group are fit for all occupations.

*Grade* 2 *Vision.* Individuals having not less than 6/12 in each eye and also those having 6/12 in one eye and not less than 6/36 in the other eye. Workpeople in this grade are fit for all industrial occupations except for the very close work essential in the manufacture and inspection of radio valves, electric lamps, certain silk yarn trades and a few others. Grade 2 vision is sufficient for all clerical work, the engineering industry and the driving of vehicles.

*Grade* 3 *Vision.* In this group are all the one-eyed people who have 6/6, 6/9 or 6/12 in the good eye, and less than 6/36 in the other eye, or who have one blind eye. The one-eyed with 6/6 in the good eye are fit for all occupations, even for those which require fine close work. The one-eyed who have 6/9 or 6/12 vision can be engaged in most trades and industries. Occupations such as coal-mining and certain operations in the engineering trades such as hammering, chipping, turning and milling, present a greater danger of injury to the eyes. It is therefore suggested that one-eyed workers should not be engaged in coal-mining or in any of these engineering operations.

* A paper read to the Association of Industrial Medical Officers, March 24th, 1945.

*Grade 4 Vision.* To this group belong workpeople who have 6/24 vision in each eye or 6/24 in one eye and 6/36 in the other. People with grade 4 vision can be employed in all outdoor occupations: building trades, carpentry, dock labour, portering and many other like trades.

*Grade 5 Vision.* To this group belong the blind and partially blind and can include all individuals with less than 6/36 vision in either eye. The National Institute for the Blind has issued several pamphlets dealing with the employment of the blind. They show how, since the beginning of the war, the blind and partially blind have been employed in hundreds of industrial occupations. Some of these are assembling of petrol tanks, crash helmets and ball bearings; bakery work; boot repairing; catering; clerical work; engineering work; and machine operating.

This subdivision of workpeople into 5 visual groups is meant to be a guide only, for the industrial medical officer will often come across workmen with 6/24 vision in each eye doing excellent work in the engineering trades where a higher vision should be required. Vision is only one of the factors necessary in the make-up of the skilled worker. High intelligence and experience often counterbalance the handicaps which arise from poor visual acuity. Such people should not be turned away from their jobs, for in the selection of the right man for each job the total mental and physical make-up of the individual should be the guide.

### *Close Work*

Fine work at close range presents a special problem in industry. Radio valve manufacture, electric lamp inspection and manufacture, fine weaving and silk hose manufacture necessitate working at 10 inches or even less from the job. This requires constant accommodation effort and convergence to a greater degree than does ordinary clerical work. In the selection of workers for these jobs there should be a full investigation of vision. The visual acuity required is 6/6 or 6/9 each eye. The muscle balance and binocular vision should also be investigated. A Maddox Wing can be used for measuring the muscle balance of the eyes for near vision, and a Worth's amblyoscope is a convenient instrument for estimating the degree of binocular vision (fusion, stereopsis and convergence). Both instruments are small and cheap. Industrial medical officers are not usually fully acquainted with the details and interpretation of muscular imbalance. It is therefore advisable that an investigation by an ophthalmic surgeon be carried out on all individuals engaged or likely to be engaged in such work. Young men and women with a a high error of refraction (latent hypermetropia) will often have 6/6 vision but will suffer from headaches when engaged at close work. In all such cases a routine examination by an ophthalmic surgeon would lead to a correction of refractive errors and of muscle imbalance and thus would prevent headaches and eyestrain from which these workers often suffer. As a general rule one can state that individuals with refractive errors, if properly corrected with glasses, suffer no discomfort when engaged on close work. Older workers wearing glasses to correct their presbyopia are just as efficient as younger workers. Investigations of the Industrial Health Research Board [1] have shown that persons engaged in very fine close work suffer from eyestrain which is in many cases relieved by the wearing of spectacles provided with strong prism (base in) to relieve excessive convergence. These investigations have been confirmed and in some factories these spectacles, which are also provided with a magnifying lens, are issued to the workers; but they are not always worn. L. B. Bourne recently reported [2] on the procedure in careful selection of workers employed in radio valve manufacture which involves close work on very fine parts. Employees are graded according to their distance and near vision, and on the degree of muscle balance of the eyes. Employees who have phorias (exophoria or esophoria) greater than five prism dioptres are not put on fine close work. The adoption of this procedure has been followed by very satisfactory results. Only a very small number of workers, about 2 per cent., have complained and asked to be transferred to another section of the factory where such fine work is not necessary.

Recent research in binocular vision has shown that not only phorias but also poor stereoscopic vision may often be responsible for symptoms of eyestrain. Ida Mann and Dorothy Archibald [3] showed that to be able to continue fine close work without fatigue one should have a well developed stereoscopic sense and good muscle balance for the near point. As a general guide one could recommend that employees engaged in very fine close work should have no hyperphoria. Exophoria or esophoria must not be greater than five prism dioptres. They should have good stereoscopic vision in addition to a corrected visual acuity of 6/6 or 6/9 in each eye. It is interesting to note that one-eyed workers with 6/6 vision in the good eye can continue working comfortably in occupations involving fine close work. This careful selection of workers for fine close work should be done in factories and in training and rehabilitation centres by ophthalmic surgeons with the assistance of an orthoptist who might carry out treatment of individuals with small degrees of muscle imbalance and poor stereoscopic vision.

### *Myopia*

The ophthalmic surgeon is often asked by myopes and parents of short-sighted adolescents whether it is safe for them to carry on with clerical work or any other type of close work. There is no evidence that close work has any effect on the progress of myopia. In the past ophthalmologists held the view that close work caused a deterioration of the sight of myopes (a progression of myopia). Recent investigations have not confirmed this opinion. Myopes whose vision with glasses is 6/6 or 6/9 each eye can carry on comfortably with fine close work (needlework, weaving, etc.). Myopes with 6/12 vision in each eye are fit for all types of clerical work. Adolescents suffering from myopia, whose corrected vision is less than 6/9 each eye at the age of 16, should be advised against taking up close work, as with the natural progress of myopia between the ages of 16 to 25 there is a likelihood of their vision further deteriorating. At the age of 21 they might have 6/18 vision only and find themselves unable to carry on with clerical work or any other type of close work with comfort. The selection of a suitable job by a high myope in adolescence will obviate many years of wasted training.

### *Latent Hypermetopia*

Railway companies insist that employees who are training as firemen and later as engine drivers should have, on entering their service, 6/6 vision in each eye without glasses. Many young men with a latent hypermetropia of 2 or 3 dioptres have 6/6 vision in each eye without glasses, and pass the necessary eyesight tests required by these companies. At the age of 40 their latent hypermetropia becomes manifest and their vision without glasses drops to 6/18. When re-examined at this age their vision is below the required standards without glasses although their vision with glasses is 6/6 each eye. These men are refused promotion from firemen to acting drivers and are given lower grade jobs with loss of wages. The same applies to drivers of public vehicles who are not allowed to go on driving. They have wasted many valuable years in training for a high grade job and at middle age are refused promotion. This could have been prevented had an ophthalmologist examined their eyes before they had taken up employment. The railways and other public transport companies should not employ men who are to be trained as drivers if their latent hypermetropia is 2 dioptres or over.

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[1] Weston, H. C., and Adams, S. (1927) Rep. No. 40; (1928) Rep. No. 49.
[2] Communication to the Industrial Welfare Society, April, 1944.
[3] *Brit. med. J.*, 1944, I, 387.

# REVIEWS

## *MASS MINIATURE RADIOGRAPHY OF CIVILIANS*

*For the Detection of Pulmonary Tuberculosis*

M.R.C. Special Report Series No. 251

By Kathleen C. Clark, P. D'Arcy Hart, Peter Kesley and Brian C. Thompson

(H.M. Stationery Office, London. 1945. Pp. 135. 3*s*.)

The publication of this report is a notable event. In addition to presenting a detailed description of the technique, it gives a comprehensive analysis of a survey made of 21,000 persons over 14 years of age in the London area drawn from the employees of two factories, and from the Civil Service personnel of a number of Government Departments. Comparison of the results of this survey with those of other surveys of larger and smaller groups by the same and other methods (fluoroscopy, full-size radiography) and in various parts of the country shows a striking similarity in the observed incidence of newly discovered tuberculous lesions, especially in the group requiring to leave work immediately for sanatorium or equivalent treatment (0·2–0·7 per cent. : 0·4 per cent. in this survey). The incidence of cases requiring out-patient medical observation, including periodic x-rays, while remaining at work was found to be 0·9 per cent., thus giving a total of 'significant' cases amounting to 1·3 per cent. of all persons examined in the reported survey.

The magnitude of the national problem will be apparent. The difficulty in present circumstances is to provide the necessary facilities for treatment and the authors of the report are not unmindful of it. To engage in intensive propaganda for this aspect of social medicine and to hold out hope if treatment is found to be necessary, only to find that full treatment in the best conditions is not forthcoming, will not promote the confidence which the method well merits. Experience has shown that, in spite of a widespread recognition of the value to be attached to mass radiography, a great deal of propaganda and reassurance is necessary in order to obtain a satisfactory proportion of volunteers, particularly among the workpeople in industrial areas. When the scheme is outlined to factory personnel, each workman sees himself already as one of the treatment group and reacts first with anxiety for himself and then with apprehension as to the maintenance of his family. The restriction of the scheme of allowances to pulmonary tuberculosis does not encourage men to volunteer for what is regarded by them as a health survey. The present reviewer has not heard workers lay so much emphasis on the possibility of victimization as might be anticipated from references in the report. There are many industries return to which after treatment for pulmonary tuberculosis would be ill-advised; and with the best will in the world the employer would be doing the 'treatment' case a disservice in taking him back.

The services of industrial medical officers in the determination of employers' policy in this matter cannot be overstressed, and yet the report emphasizes the need to uphold the myth that these men and women are so much in the pocket of employers that is is undesirable to include them in schemes of this 'confidential' kind for the amelioration of the nation's well-being. As matters are regarded at present, the industrial medical officer is well advised to maintain an attitude of detachment towards the scheme. Let him do what he can to help organize it by all means. Increasing experience will show that the employer who employs a doctor will in no way militate against the latter's overriding preoccupation with the health and happiness of the workpeople.

It would have appeared rational to suppose that a full knowledge of the physical condition of employees should be made available to the industrial medical officer in order to attain the best possible conditions of work for the persons involved. But if there still remains that mistrust of the employer which is a painful heritage of the discreditable past history of industrial relations, the authors of the report might have made the point that an opportunity was at hand to bring to notice the great help which could be given by doctors in industry in implementing an outstanding experiment. M. W. G.

## *SOCIAL ASPECTS OF TUBERCULOSIS*

By S. Roodhouse Gloyne, M.D., D.P.H.

(Faber and Faber, Limited, London. 1944. Pp. 147. 8*s*. 6*d*.)

Pulmonary tuberculosis is the most important single disease which affects men and women in the prime of their life. It is a chronic disease and therefore causes a very great amount of economic distress. In medical schools, if attention is paid to the disease at all, it is largely directed to the treatment of individuals, especially by the sanatorium regime and collapse therapy; and important as these aspects are, they are only makeshifts since we know of no better treatment at the present time. Perhaps the social aspects of the disease are much more important, and this book by Gloyne, an able observer, is greatly to be welcomed, particularly during war-time. His purpose is to set forth for students of social medicine, especially health visitors and those interested in the social aspects of tuberculosis, the problems of the seed and soil of tuberculosis as they concern both the individual and the community at the present day. In order to fulfil its avowed purpose the book must be elementary, but all the same it contains a valuable collection of simple facts about tuberculosis which ought to be known by every medical practitioner. All medical students would certainly be well advised to read the book. It starts with a short historical review entitled, 'From Consumption to Tuberculosis.' This is followed by an account of the discovery of the tubercle bacillus by Koch, and of the different types of bacillus and toxin. Chapters follow on favourable and unfavourable soils for tuberculosis, classification, manifestations at different ages, bovine tuberculosis and infection and portals of entry. The prevalence of the disease and its decline during the present century are discussed, together with a short account of its manifestations in primitive races. A chapter is devoted to tuberculosis in industry. The author points out that the latest advance along the road of protection has been the application of mass miniature radiography to industry, and he wisely stresses that to be effective it must be applied in the factory at frequent and regular intervals, otherwise it is liable to create a false sense of security. Much of the chapter is devoted to a description of the various dust diseases of the lung and their relation to tuberculosis. It is a pity that the word 'pneumonokoniosis' is used instead of the (unfortunate) legal contraction 'pneumokoniosis.' Further chapters discuss important subjects such as case finding and prevention, care and after care, and tuberculosis legislation. At the end is a short bibliography. The value of a bibliography is that it is easy for reference: this one is printed as text and therefore is not easy. A good bibliography would have enhanced the value of a useful, timely and welcome book. K. M. A. P.

### *CLOAKROOMS, WASHING FACILITIES, DRINKING WATER AND SANITARY ACCOMMODATION IN FACTORIES*

Ministry of Labour and National Service Welfare Pamphlet No. 8

(H.M. Stationery Office. 1944. Pp. 14. 1*s*.)

There is great need of authoritative information and guidance on the provision of amenities in factories and a new edition of this pamphlet deserves the widest publicity. Basic information is supplied on the arrangement and equipment of cloakrooms, washing facilities, drinking water and sanitary accommodation. The subjects are dealt with under these headings and excellent photographs illustrate the text. Emphasis is laid upon adequate supervision of the facilities when once provided; this is a matter of great importance and is often overlooked. The ideal plan is to provide changing and bathing accommodation at the factory entrance so that workers may enter the factory and immediately change into working clothing. After ceasing work they can bathe and return home in their own clothes.

Essentials of satisfactory cloakroom accommodation are detailed, and plans illustrate lay-out and space required. Means of drying wet clothes are necessary. An excellent type of locker has a slanting top preventing accumulation of litter and screen doors which facilitate inspection. Washing facilities required in different kinds of factories are described, and there is information about provision of soap, towels and nail-brushes. A good system is to fit the basins without traps and discharge the waste into a glazed channel which communicates with a trapped gully situated outside the building. Shallow footbaths provided with showers in a private cubicle adjoining a dressing-room are excellent examples of bathing accommodation. Hot and cold water or mixing valves should be provided. An adequate supply of drinking water must always be available and care taken to prevent contamination. A fountain of the upward jet variety is recommended which obviates the necessity of providing drinking vessels. The regulations of the Secretary of State for sanitary accommodation are quoted and there is information on the construction of lavatories. To ensure cleanliness it is essential that one person should be made responsible for cleaning.

A. T. J.

### *BATTLE FOR HEALTH*

By Stephen Taylor, M.D., M.R.C.P.

(Nicholson and Watson, London. 1944. Pp. 128. 5*s*.)

One of the most interesting things in this book (so far as this reader is concerned) is tucked away in the biographical note on the back turn-over of the jacket; it is the statement that 'Dr. Taylor believes that social advance springs only from a basis of factual information.' If Dr. Taylor really holds this view, which, one would have imagined, has been out of date these hundred years or more, he had better take a look at the book which he himself has written, and ask himself how much of its punch and appeal derives from mere fact, and how much from other factors. The whole feeling of the book is one of strength, activity, enthusiastic work. He has written this feeling into the letterpress, and the book develops and enhances it very greatly, with its profuse and expertly chosen illustrations to the number of no less than 91 and its 13 pictorial charts in colour. The isotype charts are particularly worthy of study by those who are so naive as to believe that social advance springs only from a basis of factual information and thus takes no account of feelings and enthusiasms. Not counting black and white (though these are bright enough colours to be sure), but including stipples, hatchings and linings, one can find more than twenty colour effects in the book as a whole. Some of the colours are there to explain, it is true. But they all stimulate. As for the symbols employed in the isotypes, there is no space to detail them here, but the point which Dr. Taylor might care to reflect upon is that they all have a feeling-effect, which is quite separate and distinct from their rational significance. Let him look, for instance, at the figure which represents a unit of infants, or at the figure which means a unit of doctors, or that which stands for a unit of deaths.

Judging from his note to the reader, Dr. Taylor has not yet found his feet in what he describes as the 'science' of teaching, for if he had he would recognize that it is not merely a science, but also an art. In a sort of flight from psychological realities, he states in his note that the pictures are not there to look pretty; as if it were a frightful crime to use artistic effect in a work designed to command a subject, to enforce attention, and to engage sympathetic interest. Adopting this larger viewpoint, one has no hesitation in suggesting to Dr. Taylor that he can include the following amongst his soldiers in Battle for Health: Nicholson and Watson who publish his book, L. John Edwards 'for the Editorial Committee,' Adprint, Ltd., London, who designed and produced it, Jarrold & Sons of Norwich who printed it, the Isotype Institute who produced the charts, Paul Rotha who edited the photographs, and a whole regiment detailed in his acknowledgments. Some of these cohorts may have been brought into the battle as press gangs, but soldiers they are nevertheless.

Dr. Taylor reviews the battlefield, examines the enemy, gives a progress report on the fight against the main killing diseases, and leads on to final sections on planning for health. The work is excellently performed, and the result is a primer of social medicine, which, one can confidently predict, its readers will have pleasure in possessing and profit in consulting. But the factual information conveyed is only a part of the total effect of the book, which, if it is not impertinent to say so, is a good deal better than Dr. Taylor knows. For as we have said, teaching, like medicine itself, is not merely or even primarily a science. It is an art.

R. F.

### *SAFETY SUBJECTS*

Bulletin No. 67 of the United States Department of Labour Division of Labour Standards

(U.S. Government Printing Office, Washington. 1944.)

This valuable little book was prepared to meet a widespread demand for a text-book for use in the training of factory inspectors. Its object is to serve as a source of basic information on industrial accident prevention. It was first produced in a mimeographed form 7 years ago, but has been constantly revised and expanded on the basis of actual industrial experience. Its information is that which is needed for daily use by the safety engineer, but the industrial medical officer will find in it much of great interest and facts which he will often want to know, and which are not readily accessible elsewhere. In 1942, 18,100 Americans were accidentally killed at their work, another 102,600 suffered permanent injuries and 2,147,000 more were injured to an extent that incapacitated each from his work for more than one day. The estimated annual cost of these accidents is 500 million pounds. Having realized the extent of the problem, the book goes on to describe the development of the accident prevention movement and methods for discovering the sources and causes of accidents. It wisely stresses that safety and prevention of accidents is the responsibility of the management. Good planning of plant and a spacious lay-out are of great importance in the prevention of accidents. Industrial accidents of all kinds are then fully discussed, but it is not possible here to mention all the information in this book which is crammed so full of facts. It is surprising to find at the end of each chapter a series of examination questions; and these rather detract from an otherwise pleasantly produced book. If available it is likely to be a useful reference book in the medical department of any large factory.

K. M. A. P.

# ABSTRACTS

**Noise in Factories.** Bull. No. 1, Derby Advisory Council on Industrial Health (1944).*

*Physiological effects.* Noise affects the organs of hearing and the contractions of the stomach. In noisy trades such as riveting and boilermaking, men tend to become deaf; 43 per cent. of riveters have some degree of deafness in both ears compared to 6–9 per cent. in quiet trades. The noise level of a pneumatic riveter is 99 decibels; the noise level of an average busy street is about 60 decibels. At 110 decibels hearing becomes feeling. Loud trades cause inner ear deafness (like senile deafness) at an early age. Authorities state that 10–26 per cent. of inner ear deafness is occupational. If there are changes of temperature or where catarrhal subjects are exposed to dust, deafness comes on more readily and previous ear disease increases susceptibility. Experiments show that there is a marked effect on the number of contractions of the stomach per minute caused by noise. This effect is believed to be a fear reaction.

*Psychological effects.* Incessant and distracting noise increases the drain of nervous vitality. Adaptation to a specific noise may take place until the individual is barely conscious of it, yet the irritation has a cumulative effect. In some cases the diminution of nervous vitality may lead to the subject becoming neurotic, and if he is neurotic already adjustment is slower. H. M. Vernon states that the 'fatiguing effect of noise is chiefly due to its effect on the faculty of attention. Noise distracts attention and therefore necessitates a more intense mental application to the task in hand.' This mental tension reduces physical and mental efficiency. Vernon considers that most noisy occupations have their effect by causing nervous irritability and strain, and that the degree of reaction varies with the individual. Hence it follows that workers assigned to noisy operations should be tested.

*Effects on industrial efficiency.* Experiments show that a reduction in noise increases efficiency and output. This applies to both motor and mental skills. But concentration and attention in greater or less degree are essential in all forms of production, and noise is a distracting influence. Adaptation to noise is a daily process, and protection against it hence will show a greater output in the early hours of the working day.

*The employee.* Workers who may have to work in noisy surroundings should be treated for their fitness to stand the conditions. This will avoid a high labour turnover and absenteeism. As deafness will occur more readily in those with catarrh or who have already had ear trouble, such workers should not be placed in noisy shops. Deafness is also influenced by the total time of exposure and the length of each separate exposure, and there is some recovery from the effects of noise with a cessation to exposure. Hence rest periods at appropriate intervals away from the noise are indicated.

*Possibilities of noise reduction.* Here the general principle is to damp out the vibration which is the cause of the noise as near as possible to its source. Sometimes this is not possible as the source of noise is not under control, e.g. street traffic noise. In such cases use must be made of isolaters or some sort of resilient damper to prevent or reduce vibration. It may be noted that special designs, as self-drives, reduce the noise considerably.

*Machines.* Sound insulation can be readily applied to units such as engines, compressors or ventilating fans, although it should be regarded as supplementary to mechanical methods for minimizing vibration at the source. But sometimes such units cannot be so designed as to neutralize completely the large inertia forces involved. A partial remedy is to tie the machine down to a solid foundation of sufficient mass to reduce the amplitude of vibration. This will leave residual vibration requiring insulation. The simplest type of vibration insulation consists of a pad or mat of some resilient, soft and durable material under the machine. Various materials are used, including hairfelt, corkboard or rubber. Haphazard insulation is useless. An intimate knowledge of the properties of the material is required so that the proper amount and size may be determined, relative to the mass and frequency of vibration of the machine.

Some types of machines require anchorage. The anchor bolts should be insulated laterally and longitudinally. The pad under the bolt head must be designed for the load due to bolt tension; that under the machine base, for the weight of the machine plus bolt tension. Steel springing is another method of insulating vibration. This is suitable for small motors, but is of limited application.

*Sound absorbents.* Where vibration cannot be controlled or control is insufficient, use may be made of commercial sound absorbents, either as wall coverings or wall linings. Below is given a few of these with their absorption co-efficients, together with common wall surfaces as comparison. The co-efficients are relative to the sound absorption of an open window through which all sound passes and none reflected. Such window is credited with 100 per cent. absorption denoted by unity:—

| | Coefficient of sound absorption per sq. ft. |
|---|---|
| Open window | 1·0 |
| Corkboard, 1 inch thick | 0·30 |
| Hairfelt, 1 inch thick | 0·58 |
| Acousti-Celstex Type BB, 1¼ inch thick, perforated from front | 0·70 |
| Felted silica fibres, 1¼ inch thick | 0·57 |
| Acoustex (Excelsior wall board) | 0·54 |
| Brick wall, bare | 0·032 |
| Brick wall, painted | 0·017 |
| Plaster on wood lath | 0·034 |
| Varnished wood | 0·03 |
| Unfinished wood | 0·06 |

*Buildings.* The most effective form of vibration insulation is to introduce discontinuities in building construction in the path of vibration; by mounting floors and walls independently of the main structure, or by putting pads under column footings, vibration and sound will be reduced. In the case of solid walls, whatever makes the wall stiffer and heavier tends to improve its sound-insulating qualities. For a hollow wall the air space between acts as a sound insulator. If filled, the effect depends on the nature of the filler. A composite panel formed of absorbent material between two thin sheets gives good insulating effects. Balsam, cotton, hairfelt or kapok give good results.

**Stress Dyspepsia in Industry.** WHITWELL, G. P. B. (1944). *Lancet*, **2**, 449.

The works doctor is particularly fortunate in being able to assess the environmental factors present in cases of dyspepsia. Some cases which are labelled 'nervous' dyspepsia could more correctly be called 'fatigue or

* The Derby Council consists of six employers, six T.U. members, and six doctors. This Bulletin is a summary of present-day knowledge on the subject of noise, prepared for local circulation.

stress' dyspepsias. In a large and modern aeroplane factory, working hours were from 55 to 84 hours a week and many employees were unused to factory life; workpeople were mostly on a 2-week change of shift, alternating day and night. The workers commonly noted that when they slept well they digested well, but they suffered a lot from dyspepsia which they attributed to night duty. Symptoms started with a regular 'change of shift' syndrome, annorexia, insomnia and constipation. In some these were the only symptoms and in others it progressed to epigastric pain, vomiting and loss of weight. Symptoms were attributed to night work and a fortnightly shift was preferred to a monthly one. This was a fallacy as it was the change rather than the night duty which caused the symptoms. Long hours of travel and work caused also cases of fatigue dyspepsia. New employees often suffered from nausea and annorexia due to the smell of hot oil and paraffin, and some vomited on entering the factory. The problem of smells has not yet been dealt with in factories; they have a profound psychological effect and cause epigastric distress in many persons. Reassurance that a smell is not harmful structurally has little effect. Change of shift often upsets the peptic ulcer case and many of these cases are particularly anxious as to the possible harmful nature of the chemicals or the paint they are required to use. It is undesirable for a peptic ulcer case to suffer nausea for any length of time. Other factors of importance are home, diet, impersonal supervision and muscular exertion. Although many people appear to develop dyspepsia under stress conditions, few contract peptic ulcers as a result of industrial conditions.

**Dermatophytosis in Industry.** PECK, S. M., BOTVINUK, L., and SCHWARTZ, L. (1944). *Arch. Dermat. Syphil.*, **50**, 170.

Two thousand one hundred and twenty-three workers in six different plants were examined for evidence of fungal diseases of the skin. The factories included two making munitions, three processing metal parts and one making glass products: 27·79 per cent. showed definite evidence of infection, 38·57 per cent. showed no evidence and in 33·63 per cent. the disease was doubtful clinically but cultural methods showed that some of these had the disease. There was no significant difference in sex incidence. The incidence was higher in winter than summer, rising from about 15 per cent. to 50 per cent. Trichophytin gypseum was the most common fungus to be found, trichophytin purpureum was also found, and trichophytin inguinale in one case. Trichophytin tests were made in 776 workers (558 men and 218 women) and 42·5 per cent. gave a positive result (52 per cent. in men, 30 per cent. in women). The trichophytin test was more often positive in patients with chemically active dermatophytosis of the feet than in those showing no evidence of the disease. Flooring of the shower room seemed to have bearing on the incidence of the disease; concrete, copper-impregnated concrete and pinewood appeared to have equal incidence. Dermatophytosis is not an important factor in loss of time among industrial workers.

**Occupational and Related Dermatoses.** Abstracts from the literature, Jan. 1940 to June, 1943. SCHWARTZ, L., and GOLDSMITH, N. R. (1944). *U.S. Publ. Hlth. Bull.*, No. 284. Pp. 179.

This volume is a continuation of Public Health Bulletin No. 226, which contains abstracts from the literature on occupational dermatitis from 1935 to 1939. Like its predecessor, it represents routine work of the Dermatoses Section of the Industrial Hygiene Division, Bureau of State Services, U.S. Public Health Service.

**Current Progress in Sterilization of Air.** MUDD, STUART (1944). *Amer. J. publ. Hlth.*, **34.**

Figures are quoted indicating the high cost of respiratory disease to industry. Days lost from this cause possibly amount to more than one-third of the total days lost from all causes of disability. The greater part of the potentially infective material expelled by persons into the air is contained in invisible droplets, which evaporate almost instantaneously. The rationale of rendering air safe from infection has been laid down in the laboratory and in controlled human environments. The means are ultra-violet irradiation, dust-suppressive measures, and the use of germicidal vapours in hypochlorous acid and of propylene and triethylene glycol. Elaboration of the practical art of providing safe air supplies is, however, not to be accomplished cheaply or through the efforts of a few people. A specialty or specialities in sanitary engineering will have to develop around air sanitation. The article concludes with a valuable list of some thirty-eight references bearing on respiratory disease in industry and air disinfection.

**The Introduction of Glycols for Air Sterilisation by a New Vaporisation Method.** BIGG, EDWARD, and JENNINGS, BURGESS, H. (1944). *J. industr. Hyg.*, **26**, 307.

Triethylene glycol vapour is being used to control micro-organisms suspended in the air, so it is necessary to develop a practical method of vaporizing known quantities of the glycol. The method adopted was designed to introduce simultaneously both water and glycol into the air at predetermined rates by boiling glycol-water solutions. The proportions of glycol and water vaporized depend on their respective concentrations, whilst their rate of introduction into the air is determined by the rate of boiling. The laboratory type of vaporizer described consists of a 5-gallon steel tank heated by a 1-kw. immersion heater connected to a 110-volt line (or to double this heat supply). An adjustable thermoswitch operates a solenoid valve which admits water into the tank. Supposing the thermoswitch is set at 260° F. and the glycol solution in the tank is 90 per cent. the temperature of the mixture oscillates between 259° and 261°, and more water—which evaporates much more quickly than the glycol—is automatically admitted into the tank at the upper temperature. Control tests were made in order to determine the amounts evaporated at various temperatures. For instance, at 266° F. the amount of water evaporated (with 1-kw. heater) was 2·5 lb. per hour, and of the glycol, 0·02 lb. Repeated tests showed that the water vapour did not inhibit the bactericidal activity of the glycol, and moreover it reduced the risks of fire, which are present with saturated heated glycol vapour. A field type of vaporizer is also described.

**Occupational Hazards in Fabrication of Magnesium and its Alloys.** FORD, C. B., and STERN, A. C. (1944). *Industr. Bull.*, **23**, 253.

Since the war the production of magnesium alloys has increased nearly a hundred times. Occupational hazards arising during its manufacture are reviewed. The greatest hazard in magnesium foundries is fire and explosion: these naturally produce casualties. Safety measures are therefore summarized. The local fire service should be warned against the use of water on any fire that may occur. The melting and pouring of sand castings should preferably be done in one-storey, non-combustible buildings. In melting the alloys chloride and fluoride fluxes and sulphur should be used to exclude air. Crucible furnaces should be so constructed that the crucibles heat uniformly, preferably by radiant heat. Special oxidation inhibitors such as boric acid, sulphur, borax or soluble fluoride salts when added to moulding sands, make it possible to pour molten magnesium alloys into damp sand moulds with no attendant reactions. When sand and not shot is used in abrasive blasting, the resulting dust contains such a high percentage of sand, and so low a percentage of magnesium dust as to be essentially non-combustible and non-explosive. With shot blasting, wet dust collectors should be used, branches and mains to the wet collector should have no pockets, and this duct work should have inspection doors not more than 20 feet

apart. Safe practices for preventing heat-treating fires include an atmosphere of 1 per cent. sulphur dioxide in the furnace, airtight clean furnaces, grinding free castings, automatic uniform oven temperature of 800° F., and a manual means 15 feet from the oven for shutting off circulating fans. Lastly, particles of magnesium during finishing operations should be controlled and disposed of.

**Health Hazards associated with the Welding Process.** QUINN, R. W. (1944). *Milit. Surg.*, **95**, 410.

Six members of the crew of a light cruiser complained of symptoms of a metallic or sweetish taste, slight general malaise followed by the sudden onset of substernal pain, chills and fever up to 103·6° F. They had a marked leucocytosis, one being as high as 18,000. The symptoms appeared three to six hours after breathing toxic amounts of metal fumes produced in welding. Each of these men had been exposed to a high concentration of the fumes for at least a four-hour watch. There was no ventilation as the ventilating system to the compartments was under repair. The syndrome was considered to be metal fume fever, and all the men recovered completely. The literature of health risks caused by welding is reviewed.

**A Welding Fume Sampler.** SILVERMAN, LESLIE, and EGE, JOHN F., Jr. (1944). *J. industr. Hyg.*, **26**, 316.

The sampling apparatus described affords a rapid method for estimating the concentration of welding fumes in ship construction and other welding operations. It was designed primarily for measuring fume concentrations when welding upon black iron with coated welding rods. The sampler consists of a steel suction pump of 600 c.c. volume, with two pieces of telescoping brass tubing at the nozzle. Between them is a disc of filter paper, and the telescopic tubing arrangement permits rapid changing of the papers. An iron stain is produced on the paper, of a depth proportional to the fume concentration and the number of strokes of the pump. The stains were calibrated by creating fumes in a 1200 cubic foot chamber, and pump and electrostatic (A.C.) precipitator samples were taken simultaneously. The precipitator samples were weighed in order to give the total fume concentration. Standards were taken with one to five strokes of the pump. The efficiency of the paper in retaining the fume may be 99 per cent.

**The Place of the Range-Finding Test in the Industrial Toxicology Laboratory.** SMYTH, HENRY F., Jr., and CARPENTER, CHARLES P. (1944). *J. industr. Hyg.*, **26**, 269.

This investigation was designed to ascertain the toxicity of new organic chemicals originating in a commercial organization. During the past year 26 new chemicals required experimental study, and though it is too early to say how many will become articles of commerce it is certain that some of them will find no useful application, so it would be useless to make detailed investigations on their toxicology. Later, when the commercial possibilities of the new chemicals become apparent, their toxicity can be tested in detail, but all that need be ascertained at present is to be able to compare them roughly against the toxicity of well-known and well-investigated chemicals.

In order to ascertain oral toxicity, six albino rats were given a single dose of the diluted chemical by stomach tube, amounting to 10, 1, 0·1, etc. g./kilo body weight. Other tests were made until two dosages were found, differing by a multiple of 10, one of which killed some or all of the animals within 14 days, and the other of which killed some or none of them.

Skin absorption tests were made by giving dosages differing by a multiple of 10 to six guinea-pigs, the sample, in absorbent cotton, being retained over the clipped abdomen of the animal for four days. Saturated vapour effects were determined by exposing groups of six rats to air saturated with the vapour of the test material for periods up to eight hours. Other experiments were made until the exposure times were ascertained which killed all six rats within a fortnight of inhalation and those which killed none of them. Skin irritation tests were made (on rabbits) on a similar principle, and as a frequent risk is incurred by splashing chemicals into the eye, series of tests were made on the cornea of rabbits with various concentrations.

**Bagasse Disease of the Lung.** SODEMAN, W. A., and PULLEN, R. N. (1943). *New Orleans med. surg. J.*, **95**, 558.

The report of a case of a white male aged 26 complaining of shortness of breath and cough but no haemoptysis. Twenty weeks before admission he had worked in bagasse dust. On examination there were signs of consolidation at the right base and fine rales through both lungs. His temperature was 100° F. Blood counts showed a leucocytosis. Sputum contained no tubercle bacilli on five occasions. X-ray showed a miliary ground-glass mottling throughout both lung fields. Biopsy taken during the sixth week of the disease reveals pulmonary tissue in which there are embedded several 'spicules' of an irregular foreign material. This is similar to bagasse material when placed under the microscope. Two months later the patient was better and x-ray showed a complete clearing of the lung field. Another case had a necropsy, and microscopic findings in the lung showed an increase in the fibroblast reaction of the interstitial tissue. Small needle-like spicules could be occasionally seen in these areas when subjected to polarized light. The alveolar cells were very large and cytoplasm was foaming. The picture appeared, therefore, to be an organic pneumokoniosis, but the mechanism of the changes, and the nature of the stimulus set up by the bagasse dust to produce the cellular reaction, remain obscure.

### Poisoning by Soluble Barium Compounds

**Pa Ping, or Kiating Paralysis,** ALLEN, A. S. (1943). *Chin. med. J.*, **61**, 296; **"Pa" Disease,** DU, K. T., and DUNG, C. L., *ibid.*, 302; **Acute Poisoning by Common Salt containing Barium Chloride,** *ibid.*, 303; **Pa Ping,** HUANG, K. W., *ibid.*, 305; **The Absorption, Fate and Concentration in Serum of Barium in Acute Experimental Poisoning,** CHOU, C., and CHIN, Y. C., *ibid.*, 313.

Pa Ping or Kiating paralysis is a disease common in certain areas of China, including Kiating, Wutungchiao, Omei, Chengtu, Ipinand, Lushien. This is a large salt-producing area and barium chloride in concentrations as high as 25·69 per cent. have been found as an impurity. The disease has been found mostly in males, though some females have been affected. The symptoms which usually occur soon after a meal consist of nausea, vomiting, diarrhoea sometimes associated with abdominal pain, general weakness, abnormal sensation of the skin and paralysis of the extremities. This last symptom is the most characteristic, and causes the disease to resemble Family Periodic Paralysis. The paralysis first develops in the lower and then gradually affects the upper extremities. The pupil reaction is always preserved and the mentality remains clear. The blood pressure is elevated, the pulse rate reduced and body temperature lowered. The mortality ranges from 5 to 10 per cent. Necropsy revealed parenchymatous degeneration and congestion of the liver, congestion and parenchymatous degeneration of the tubules in the kidney, infiltration of the mucosa and submucosa of the duodenum with eosinophils, and hyaline degeneration in muscle. Chromatolysis was also observed in the nerve cells in Clarke's column. Animal experiments produced similar symptoms and showed that barium is absorbed from the intestine. Serum concentrations of 2·2 mg. per 100 c.c were obtained in water after ingestion of barium by mouth; but concentrations over 5 mg. per 100 c.c. after parental injection. Half the barium was removed from the blood stream in 15–30 minutes, and three-quarters

in 2 hours. Although the soluble barium salt may be precipitated rapidly in the gut by inorganic sulphate, such precipitation does not occur in the blood stream. Barium appears to form barium proteinate in the serum. A minute amount of barium in the cerebro-spinal fluid produces convulsions. Treatment consists of giving sodium or magnesium sulphate in sufficient doses to precipitate the barium as insoluble sulphate. If the disease is suspected treatment should be immediate, since the absorption of barium chloride is extremely rapid. Prevention may be accomplished by chemical analysis of brine at the well-head of all salt wells.

**The Determination of Barium in Atmospheric Dusts.** YAGODA, HERMAN (1944). *J. industr. Hyg.*, **26,** 224.

In the manufacture of ignition powders and incendiary bombs toxic dusts are produced, the principal constituents of which are barium oxide and barium nitrate. In order to estimate the concentration of the barium a method has to be devised which is not vitiated by the presence of the other components of the dusts. The test devised is based on the fact that when barium sulphate is precipitated from solutions containing potassium permanganate a marked pink colour is imparted to the precipitate, which consists of mixed crystals of barium sulphate and potassium permanganate. The precipitate was collected in a confined area, suitable for colourimetric estimation, and thereby the barium could be estimated over a range of 2–200 micrograms. A great many precautions had to be taken in order to get a valid result. The physico-chemical aspects involved in the formation of the coloured mixed crystals were investigated, conditions being thereby formulated which permitted the detection of 2 micrograms of barium at a dilution limit of 1 in a million.

**Studies on the Toxicity of Commercial Benzene and of a Mixture of Benzene, Toluene and Xylene.** HOUGH, V. H., GUNN, F. D., and FREEMAN, SMITH (1944). *J. industr. Hyg.*, **26.** 296.

A prolonged and detailed examination was made of the reaction of dogs to the vapour of commercial benzene and of a mixture of benzene, toluene and xylene in the proportions of 60 : 30 : 10. Two groups of four dogs were exposed for a total period of 123 weeks, any dog dying during the tests being replaced by another. The dogs were placed in the exposure chambers every weekday for a total period of 42 hours, the concentration of benzene vapour usually being 1100 parts per million, and of the mixed solvents, 1050 parts. All the four dogs exposed to mixed solvents survived, but only two of the other group, the substituted dogs surviving 4–42 weeks. Haemoglobin estimations, red cell counts and white cell counts were made every week, and no consistent change was observed in the haemoglobin and red cells, but the leucocytes decreased in both groups of dogs. From an initial count of about 14,000 per cubic millimetre the leucocytes fell, in 7 of the 13 animals exposed, to below 5000, the benzene group of dogs being substantially more affected than the others.

Estimations of the urinary sulphates were made every week, and the benzene dogs invariably had a higher percentage of conjugated sulphates than the others. The amount of conjugated phenol in the blood of the benzene dogs was likewise higher, and so was the phenol in the urine. The free phenol in the blood and urine was increased as well as the conjugated phenol.

During 42 weeks of the total exposure period the concentration of the benzene vapour was reduced to the same level as that of the benzene in the mixed solvents, and it was found that the leucopenia, conjugated urine sulphates and blood phenols became practically the same as in the dogs exposed to the mixed solvents. That is to say, the effect of a given quantity of inhaled benzene did not appear to be altered by its admixture with toluene and xylene.

**Cadmium Poisoning in Industry.** SPOLYAR, LOUIS W., KEPPLER, J. F., and PORTER, HERMAN G. (1944). *J. industr. Hyg.*, **26,** 232.

Cadmium poisoning in industry occurs from the accidental absorption of fumes or dust by way of the respiratory tract, and irritation of the naso-pharynx, together with cough, are manifested a short time after exposure. Up to date 59 cases of cadmium poisoning through the respiratory route have been reported, and the present report describes five additional cases, including one death. The men were employed in putting a flange on to 6-inch pipes by heating one end until cherry red in colour, and then creating the flange. For reasons unknown, the men were on one occasion supplied with pipes coated with cadmium, and on heating they emitted a dense yellowish-brown fume. After exposure for a total period of 4–8 hours all the men became ill and had to give up work. The most frequent immediate symptoms were irritation of the throat and pain in the chest. Cough, headache and dizziness were usually present, and some 20–36 hours after exposure the patients had symptoms suggesting pulmonary oedema, namely, dyoponea, pain in the chest and persistent cough. Recovery occurred in 7–11 days after exposure, and x-ray examination showed that, four weeks after exposure, the men were free from any residual chest symptoms. The mortality rate of the known cases of cadmium poisoning is 15 per cent. and in the present series the man who suffered the most exposure (8 hours in all) died after five days. Before death he was said to be 'fighting for breath,' but no post-mortem was allowed.

**The Modern Treatment of Cyanide Poisoning.** CIREN, K. K., ROSE, C. L., CLERVES, G. H. A. (1944). *J. Indiana State med. Assoc.*, **37,** 344.

Sodium and potassium cyanide are used for extracting gold and silver from their ores, electro-plating, cleaning of metal in dip and electrolytic processes, for organic synthesis, for dehairing hides, and for partial sterilization of soil. Hydrocyanic acid is used for fumigation of ships, flour mills and other buildings, the control of scale insects on citrus trees, and fumigating of nut meals, beans, peas and seeds of different kinds. Many suicides are achieved by its use. The symptoms of poisoning consist of a sudden feeling of illness, vomiting and convulsions. The signs are a bitter almond odour in the breath, rapid respiration followed by slow gasping, rapid pulse, cyanosis and coma. The diagnosis can be proved by examining the gastric contents for hydrocyanic acid if it has been taken by mouth, or if the patient has been exposed to an atmosphere containing the poison by examination of the venous blood. The treatment suggested consists firstly of allowing the patient to breathe amyl nitrate, until 10 c.c. of a 3 per cent. solution (0·3 g.) of sodium nitrate can be injected intravenously followed by 50 c.c. of a 25 per cent. solution (12·5 g.) of sodium thiosulphate. Fifteen cases have been treated in this way, and fourteen of them recovered completely. The case that died had absorbed a large amount of cyanide and was too far advanced when antidotes were administered.

**Some Epithelial Changes in Fluorosis.** SPIRA, L. (1944). *J. Hyg., Camb.*, **43,** 400.

The action of fluorine consists of its ability to precipitate calcium salts stored in the body. The protracted ingestion of the halogen may bring about the reduction of calcium in blood and tissues to a dangerous level. The skin, teeth, nails and hair and other tissues of ectodermal origin are principally affected by fluorine. Epithelia of mouth, salivary glands, naso-pharynx, conjunctivae and lachrymal glands may be affected. Signs and symptoms are produced which are similar to an infection of the upper respiratory tract: it is suggested that these may be due to loss of calcium in the body.

**Incidence of Dystrophies caused by Fluorine in Organs regulated by the Parathyroid Glands.** SPIRA, L. (1944). *J. Hyg., Camb.*, **43**, 402.

This describes the incidence of lesions ascribed to fluorine in a series of 1700 people, 850 men and 850 women, belonging to different spheres of life and coming from various parts of the country. The average age was 25. Onychorrhexis, that is longitudinal striation of the nails in both fingers and toes, was found in 98 per cent., leukonychia was present in 70 per cent. in fingers, and 7 per cent. in toes, and brittleness occurred in 31 per cent. (23 per cent. men and 39 per cent. women). The incidence of dental dystrophies was mottled teeth 48 per cent., gingivitis 17 per cent., toothless maxilla and completely edentulous 10 per cent., horse teeth 10 per cent. and separated teeth 10 per cent. Alopecia was found in 224 men and 221 women (26 per cent.). Dystrophies of the skin included 'dhobi-itch' in 1000 (59 per cent.), furunculosis 31 per cent., urticaria 31 per cent., warts 17 per cent. and freckles 11 per cent. Hallux valgus was found in 511 men and 588 women (69 per cent.). These dystrophies should be regarded as easily detectable signs of a serious disturbance of the calcium metabolism of the body. Fluorine is a poison of which the action in many respects is similar to that of arsenic.

**The Significance of Absorbed Radium as indicated by the Coefficient of Elimination.** HOECKER, FRANK E. (1944). *J. industr. Hyg.*, **26**, 289.

It is considered that 0·1$\mu$g. of radium is the maximum safe tolerance limit for radium which is 'fixed' in the body, but the term 'fixed' is ambiguous, for the radium is never really fixed. Even after 20 years in the body a small portion continues to be eliminated at a gradually diminishing rate. Martland and others have shown that the occurrence and the type of disease associated with internal radium are related to the quantity and the period of its retention in the body. The early symptoms, occurring in those individuals who have comparatively large amounts of radium deposited in their bodies, are anaemic and jaw necroses, while the late symptoms, observed in those who have ingested smaller amounts of radium, are crippling bone lesions due to marked decalcification. Elimination rates of about 0·005 per cent. of radium per day have been reported by several investigators in girls who have retained 14–24 micrograms of radium acquired 10–14 years earlier, and the author of this paper suggests a formula for ascertaining a 'co-efficient of elimination,' based on the view that the amount eliminated at any time is proportional to the amount present and the period it has been retained in the body. The data obtained by various investigators, which relate to periods of 5–200 months in the body, agree fairly well with the mean curve against which they have been plotted. Deviations from the curve may be due to variable factors such as metabolism and diet. Some of the data were calculated in respect of the radon exhaled in the breath as well as of the total radium in the body, and it was found that the total radium figures were generally slightly in excess. Probably this was owing to some of the radium being comparatively inaccessible to the blood stream as it was deposited in the bones.

**Aluminium Therapy in Silicosis—an Experimental Study.** GARDNER, LEROY U., DWORSKI, MORRIS, and DELAHANT, ANTHONY B. (1944). *J. industr. Hyg.*, **26**, 211.

In 1937 Denny, Robson and Irwin stated that silicosis could be prevented by the inhalation of powdered metallic aluminium, and in 1932 Kettle had shown that quartz particles could be neutralized by coating their surfaces with an insoluble material such as colloidal iron hydroxide. The authors have been experimenting with gelatinous alumina prepared in various ways. They injected quartz in solutions containing 0·3 per cent. of the hydroxide, and found that animals remained well and healthy after repeated injections. When dried precipitated alumina was ground up, and suspensions of the powder and quartz were inhaled, the inhibitory action of the alumina still persisted. A group of 25 guinea-pigs was exposed for 8 hours a day and 6 days a week to air containing 0·75 mg. per cubic foot, and they developed no significant reaction in 14 months. Other tests showed that the effects of exposure of guinea-pigs to infection with tuberculosis of the lungs were not increased by the associated alumina. In further experiments guinea-pigs which had been exposed to hydrated alumina for 8 months were kept for 48 hours a week in air containing about 600 million particles of quartz per cubic foot, and even after 17 months they showed no specific silicotic change. These and other tests verified the conclusions of Denny, Robson and Irwin that aluminium in proper form constitutes an effective inhibitor of quartz in a living host, and the work of the present investigators showed that aluminium hydrate possesses certain advantages over metallic aluminium.

Hydrated alumina inhalation has already been shown to cause regression of immature silicotic lesions in human beings, and to prevent the further enlargement of fully developed fibrous nodules. Of the 34 silicotic cases treated by Crombie, Blaisdell and MacPherson in 1944, 55 per cent. showed symptomatic relief and 33 per cent. showed improved respiratory function tests. The present investigators have made tests on 5 iron ore miners, using aluminium powder, but the symptoms were relieved only in one case. Of two lead miners treated with aluminium hydrate one showed a successful result. Aluminium therapy should be administered only under close medical supervision and should not be used to the exclusion of recognized methods of dust control.

**Experimental Studies on the Toxicity and Potential Dangers of Trinitrotoluene.** VON OETTINGEN, W. F., DARCHUE, D. D., SNYDER, R. K., HORSEKER, B. L., MONACO, A. R., LAWTON, A. H., SWEENEY, T. R., and NEAL, P. A. (1944). *U.S. Publ. Hlth. Bull.*, No. 285. Pp. 78.

Contact with TNT. causes yellow discoloration of the skin, nails and hair. The vapours and dust cause irritation of the mucous membranes with sneezing, sore throat and irritant cough. Dermatoses include superficial erythema which may become thickened, papules, itchy eczema, especially in uncovered parts of the body, and vesicles may be formed. The skin of the scrotum and thigh is especially sensitive. Skin rashes are more frequent in women than in men. Frequent complaints referring to the gastro-intestinal tract are distress, nausea, vomiting, loss of appetite and diarrhoea. Tenderness over the right epigastric region may indicate involvement of the liver. The most serious sequelae of TNT. poisoning are jaundice and toxic hepatitis which may end in yellow atrophy of the liver. The mortality rate is 25–30 per cent. Some believe that liver injury leads to anaemia, others assume that destruction of blood precedes liver damage. Reduction of the red blood cells and of the haemoglobin is the most conspicuous finding in early TNT. anaemia, and may be associated with fragmentation of the red blood cells, stippled cells, reticulocytosis and eosinophilia. Relative lymphocytosis appears to be the most common change of the white blood-cell picture. Cyanosis of the lips and ears, which is more frequent in cold weather, may be due in part to the formation of a chromogenic pigment derived from TNT. and in part to the formation of methaemoglobin. Effects on the nervous system largely result from anoxia and consist of dizziness, headache, fatigue and sleepiness, but in severe cases may be delirium, convulsions and coma. Signs of peripheral neuritis and pain in certain muscle groups are not infrequent. Vasomotor irregularities, palpitation, oppression in the chest and bradycardia have been reported. In women, menstrual irregularities occur. Urinary symptoms include urgency of micturition, lumbar pain, albumin and casts. Various tests, such as those devised by Webster, indicate exposure to TNT. Experimental

work is reported, designed to answer some of the problems relating to TNT. The principal ones are:

(a) Whether or not pure TNT is less dangerous to handle than an impure product.
(b) How important is the skin as a route of absorption of pure TNT.
(c) What is the maximal permissible concentration of TNT in the air.
(d) Is there any evidence as to the effect of various dietary measures in the susceptibility to TNT or to TNT poisoning.

Spectrophotometric methods were developed for the determination of 2, 4, 6 trinitrotoluene, 2, 6 dinitro-4-hydroxylaminotoluene, and 2, 6 dinitro-4-aminotoluene. In dogs the latter could be detected before the Webster test became positive, and after it had become negative. Rubbing 500 mg. of pure TNT into the skin of the palms and protecting the hands with rubber gloves for a period of 8 hours resulted in the excretion of only traces of 2, 6 dinitro-4-aminotoluene in the urine of two human subjects during the exposure, and for 15 hours subsequently. This is in marked contrast to the excretion as 2, 6 dinitro-4-aminotoluene of 3 per cent. of 1 mg. of TNT per kg. body weight taken orally by human subjects. These experiments, togther with animal experiments in dogs and swine, showed that pure TNT is absorbed through the lungs and gastro-intestinal tract, and in only the smallest amounts through the skin. The toxic effects observed in these experiments over a period of several months are mainly characterized by disturbance of the central nervous system, moderate anaemia of peripheral origin, and irritation of the gastro-intestinal tract and urinary bladder. No animal developed injury to the liver. It remains to be seen if amino derivatives of TNT are more hepatotoxic, in which case toxic hepatitis in TNT workers might be explained by greater production of these metabolites in man. The anaemia-producing action of TNT in animals is peripheral and of temporary nature. It is, however, conceivable that susceptibility may be increased by exposure to other chemicals, and in such cases the peripheral destruction may assume such proportions that the hyperactivity of the blood-forming organs finally leads to their exhaustion, resulting in the picture of an aplastic anaemia. Milk and ascorbic acid added to a balanced maintenance diet did not reduce over a period of 12 weeks the toxic manifestations produced in dogs by the oral administration of 50 mg. of TNT per kg. body weight.

**The Metabolism of 2 : 4 : 6-trinitrotoluene** (α-TNT). CHANNON, H. J., MILLS, G. T., and WILLIAMS, R. T. (1944). *Biochem. J.*, **38**, 70.

An attempt was made to obtain information on the fate of TNT in the body by means of experiments on rabbits. From the urine of these animals when fed on α-TNT, 2 : 6 dinitro-4-hydroxylaminotoluene, 2 : 6 dinitro-4-aminotoluene and 2 : 4 dinitor-6-aminotoluene were isolated, which indicated the presence of a reduction mechanism. In addition TNT may also be oxidized. Experiments with trinitrobenzyl alcohol in attempts to establish the origin of the red pigment indicated the probable existence of an oxidation mechanism, since only α-TNT and 2 : 4 : 6-trinitrobenzyl alcohol would cause red pigment excretion. Present knowledge of detoxication mechanisms suggests that the glucuronides of TNT urine must arise from TNT oxidation products. Administration of TNT does not cause a rise on ethereal sulphate excretion; this is some evidence that trinitro-*m*-cresol is not formed. The glucuronides of TNT urine are probably trinitrobenzyl glucuronide or dinitroaminobenzyl glucuronide or a mixture of both. Hydroxylamine provides an example of the production of a more toxic product in a so-called detoxication mechanism. Hydroxylamine is also a powerful methaemoglobin former in vitro. Since the first stage in the biological reduction of TNT is the formation of dinitrohydroxylaminotoluene, there is produced a very reactive compound which may be harmful to the blood, and may have toxic effects on some of the enzyme systems. The hydroxylamine can be detoxicated by conversion into the relatively non-toxic dinitroaminotoluenes and its toxic effects will depend on the rate at which this conversion occurs. While the conversion takes place in vivo, it is by no means complete, for the hydroxylamino and the amino compounds are excreted in the urine in roughly similar amounts. The formation of dinitrohydroxylaminotoluene may therefore partly explain the toxic action of TNT. Doses of TNT up to 150 mg./kg. are eliminated in 24 hours, larger doses require up to 48 hours; 47 per cent. of the TNT administered is excreted as glucuronides and 30 per cent. as aromatic amino compounds estimated as 2 : 6 dinitor-4-aminotoluene. The aromatic amino compounds include not only dinitroaminotoluenes but possibly dinitroaminobenzyl alcohol conjugated with glucuronic acid. Trinitrobenzylglucuronide is also a likely constituent. The 2 : 2′ : 6 : 6′-tetranitro-4 : 4′-azoxytoluene isolated by previous workers is not a metabolic product; it is absent from freshly voided urine and is formed from dinitrohydroxylaminotoluene during the extraction procedures.

**The Significance of Anaemia among Women Factory Workers.** BARRIE, H. J. (1944). *Industr. Welfare*, Nov.–Dec., 184.

It was found by visual inspection that women with a haemoglobin level of 80 per cent. or less could quickly be recognized, and many of those with haemoglobin values between 80 per cent. and 90 per cent. were also identified. In one investigation 2532 factory women were inspected and 596 of them were tested. Of this number 68 had 81–90 per cent. haemoglobin, 89 had 71–80 per cent., 44 had 61–70 per cent. and 31 had 36–60 per cent. A study of the relationship of anaemia to age showed one peak at the age period 16–20, and another at 41–45. A group of 167 of the anaemic women were given tablets of iron sulphate for four weeks, and all of those who had an initial value of 75 per cent. haemoglobin or less improved significantly, but 11 per cent. of the women with an initial level above 75 per cent. failed to show any improvement. Of the 88 women questioned about their subjective feelings, 63 per cent. claimed to have an improved appetite and more energy, whilst 30 per cent. felt no improvement and 7 per cent. felt worse. The investigator summarizes his results by affirming that he knows ' of no field of medicine where one could discover from three to six seriously ill, but curable, people every hour, or where treatment is so cheap. Four weeks' iron treatment costs approximately 2*s.* 6*d.*'

**Physiologic Aspects of Traumatic Shock.** AUB, JOSEPH C. (1944). *J. industr. Hyg.*, **26**, 183.

Traumatic shock comes on slowly after injury, and progresses more or less relentlessly to death if it is not treated. This type of shock must be differentiated from primary shock, which is characterized by syncope, fall in blood pressure and vasodilatation, and is short in duration. Traumatic shock is often associated with other conditions such as haemorrhage, and burns, if present, may constitute a serious complication. It is not yet definitely decided how far the toxic factor is responsible, but infection plays an important part. Shock has been defined as a circulatory deficiency, characterized by a decreased volume of blood, reduced cardiac output and haemo-concentration. There is too little blood in too big a system, and haemorrhage alone can produce it. The loss of 4 per cent. of the total body weight in blood is ample to produce shock, and sometimes the loss of 2·5 per cent. is sufficient, especially when there is a loss of body fluids by diarrhoea, vomiting, burns and excessive perspiration.

Numerous theories of shock have been formulated.

Acidosis appears to be a contributing factor, and the view that a toxin is produced in the traumatized area is supported by the fact that if an extremity of an animal is traumatized and tied off with a tourniquet, profound shock may be induced when the tourniquet is released.

Therapy should be directed to increase the blood volume, and to be effective the treatment should be applied before the individual is in profound shock. Also it is essential that enough red cells be present in the blood, and that it be sufficiently oxygenated. Transfusion of blood plasma is often sufficient, but after considerable haemorrhage whole blood transfusion is indicated. In addition, fluids should be given by the mouth, if possible, and the foot of the bed may be raised to aid in the return of venous blood. Sufficient morphia may be given to reduce pain sensibilities, but excess must be avoided. Probably the best and safest anaesthetic is ether, which should be light with administration of plenty of oxygen.

**Some General Principles underlying the Primary Local Treatment of Burns. A Review.** LEVENSON, STANLEY M. (1944). *J. industr. Hyg.*, **26,** 156.

The paper reviews recent literature on the primary local treatment of burned areas and gives 64 references. The local loss of plasma-like fluid is the result of an increase in capillary permeability; the loss of fluid is both external, as evidenced by surface ooze, and internal, as evidenced by increased lymph flow from the burned area and the development of subcutaneous oedema. The internal loss is usually the greater, and in general the greater the area burned the greater the fluid lost. In highly vascular regions such as the face it is specially great. Loss of plasma, with consequent reduction of the circulating blood volume, is probably the most important factor in the pathogenesis of burn shock. The external ooze can be stopped by applying a substance to the burned area which forms an eschar. Tannic acid-silver nitrate controls the surface loss in a few minutes, whilst triple dye takes many hours. However, escharotics do not limit the amount of fluid lost into the subcutaneous tissues. This may be reduced by pressure dressings and close-fitting plaster casts.

In second-degree burns there is only partial destruction of the skin, and healing may proceed rapidly from the residual epithelial elements, but in third-degree burns the entire thickness of the skin is destroyed, and healing can only proceed after the destroyed tissue has sloughed and granulations have formed. Epithelialization can take place only from the skin edges, unless skin grafts are applied. Escharotics, as contrasted with bland ointments, are liable to injure viable epithelium, and the healing of second-degree burns takes place earlier if petroleum jelly ointment is used rather than tannic acid-silver nitrate or triple dye. Also with tannic acid treatment jaundice and other evidences of liver damage are seen more frequently than when bland ointments are used, owing to the toxicity of the agent absorbed. Sulphonamides, if used locally in soluble form, may be absorbed in toxic amounts, but with 5 per cent. sulphathiazole emulsion absorption is relatively slow. In any case sulphonamides should not be administered orally or parenterally until the initial oliguria, which often appears in burned individuals, is superseded by an adequate urinary output.

Burns may become seriously complicated by infection. The greatest source of contamination arises from the respiratory secretions of individuals handling the patient, and next in importance are the materials which come into contact with the burned areas. Routine washing of burns is usually unnecessary if triple dye or pressure dressings are used. Dressings should be done at infrequent intervals, the first dressing being left in place for about two weeks.

**The Asbestos Corn.** ALDEN, H. W., and HOWELL, W. M. (1944). *Arch. Derm. Syph. Chicago*, **49,** 312.

Ninety-nine out of 167 men, who used a natural form of asbestos called amosite in a naval shipyard, developed small painful warts or corns on their hands. In the first place workers with these lesions complain of a pricking sensation, and say that they can feel small splinter-like foreign bodies which they are unable to extract. However with rubbing or neglect the sensation disappears, but in one or two weeks a small hard wart appears which gradually grows to the size of a split pea. Frequently these tumours have a tiny black centre which it is not possible to remove. At this stage they are tender on pressure and interfere with work. Later there is further cornification. These corns are most common on the tips of the fingers, knuckles and thick-skinned areas of the hand. X-ray examination shows no evidence of any radio-opaque foreign body. Biopsy specimens from 4 patients revealed extreme thickening of the surface epithelium with hyperkeratosis. The dermis though fibrous showed no inflammatory changes. No foreign bodies were found in the sections. Nevertheless there is little doubt that they are the cause of the lesions. Treatment consists in removing the hard centre with a suitable instrument. No satisfactory method of prevention has been found.

**The Employment of Cardiacs.** POOLE, F. E., and BENT, J. R. (1944). *Industr. Med.*, **13,** 479.

A group of 777 persons, 451 men and 326 women, were investigated in a consideration of the placement of the cardiac in industry. The cardiac group was chosen because it is the most difficult group of physically handicapped to place. The nature of heart disease with progressive disability accounts for the difficulty in employment. The man who has lost an arm, a leg or an eye has a permanent disability which can be easily rated, and when properly placed in a suitable occupation presents no further difficulty. Placement of cardiacs is also complicated by a fear of lay supervisors that they may suddenly drop dead. The average age of the men was 32, and of the women 26. They were placed on ground-level work, involving no heavy lifting or excessive walking or standing. It was found possible to employ them in 99 out of 353 occupations in the aircraft works where the investigation was carried out. They did not differ significantly from the ordinary workers in pay rates or termination of employment. Cardiacs employed during the two-year period covered by the study represented 3 per cent. of all applicants examined. In the factors of sickness absenteeism, medical treatments, workmen's compensation and group insurance, their record was better than that of the average employee; a poorer record was evidenced only in the duration of employment. It is clear, therefore, that those handicapped by cardiac lesions can be successfully employed in industry within the limit of their physical ability, but each one is an individual placement problem.

**Role of Industrial Medicine in the Rehabilitation of Veterans.** JOHNSON, J. F., and HOFFMAN, H. V. *J. Amer. med. Ass.*, 1944, **126,** 1073.

Manufacturing industry in the past has employed about 20 per cent. of all people gainfully occupied; 80 per cent. of them worked in factories with less than a total of 500 employees. The average number of employees in factories in the United States is 42. Industry, especially the small plants, need a true record of the physical and mental status of returning ex-servicemen for proper job placement. An agency is urgently needed to perform this evaluation. Eighty-five per cent. of men now returning from the Forces are satisfactory employees, and differ little from the civilian industry. Some ex-servicemen need advice in reconstructing their life, but the need for such reconstruction frequently existed before they entered the service.

# PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

## THIRTY-EIGHTH MEETING

The thirty-eighth meeting of the Association was held in Birmingham on January 25 and 26, 1945. The meeting on January 25 was concerned with private business (reported below). On January 26, in the morning, visits were paid to various iron foundries in the Midlands through the courtesy of a number of employers. In the afternoon a film was shown and papers read on health in foundries (*v.i.*) at the Birmingham Accident Hospital. In the evening the Association held a dinner, the first since September 1939, at the White Horse Hotel. The principal guest was Dr. R. E. Priestley, Vice-Chancellor of Birmingham University.

### *Business Meeting, Queen's Hotel*

In opening the meeting on Thursday, January 25, the chairman, Dr. J. C. Bridge, thanked the Birmingham Group for inviting the Association to hold this meeting in their city, and for making the necessary difficult arrangements. It was particularly fortunate that, once again, the Association had been able to arrange a dinner. This said much for the catering potential of the Midlands.

*Representatives on Outside Bodies.*—Drs. N. T. Glynn (Birmingham) and C. L. Potts (Redditch) were elected to represent the Association on the British Council for Rehabilitation.

Drs. J. C. Bridge (London) and P. Pringle (London) were elected to serve on a committee of the Central Council for Health Education concerned with propaganda relating to the care of the feet. This committee had been set up at the request of the Minister of Health.

*B.M.A. Committee on Charter for Health.*—It was reported that the Council of the British Medical Association had formed a committee to prepare for the information of the public a statement of the profession's views and suggestions on such important matters as housing, nutrition, occupation, health education, and leisure. Dr. N. T. Glynn (Birmingham) had been invited by the Council to serve on this committee as the representative of industrial medicine. He made a short statement outlining the constitution of the committee and the preliminary work it had accomplished. He himself had been asked to submit a memorandum on occupation in relation to health. Points he proposed to cover included full employment, adequate pay, the worker's suitability for his job, conditions at work, the aims of an industrial health service, welfare services, hours of work, holidays, canteens, and the journey to work.

*War-Time Rest Breaks Scheme.*—The following resolution proposed by Dr. J. G. Billington (Birmingham) and seconded by Dr. Alice Peters (Ministry of Supply) was unanimously agreed—

> "The Association of Industrial Medical Officers realise and appreciate the good work that has been and is being done by the War-Time Rest Breaks Scheme for industrial workers in preventing illness and breakdown and in restoring workers to full health. The Association considers that the Scheme is worthy of continual support and steady development."

The Honorary Secretary was instructed to send a copy of the resolution to the Secretary of the National Committee of the Scheme.

*Registration of Specialists.*—The chairman reported that he had been in communication with the Registrar of the General Council of Medical Education and Registration of the United Kingdom. He wished to find out something of the position of industrial medical officers in relation to the proposed registration of specialists. He had been informed that as the law stands at present the Council has no power to designate any registered medical practitioner as a specialist in the medical register; but in the event of fresh legislation every practitioner should have at least the right to apply for registration as a specialist.

*Foreign Relations Committee.*—Dr. Pringle proposed the re-formation of the Association's committee on foreign relations. It was now an opportune time to explore the possibility of opening relations with similar Associations to our own in foreign countries. The matter was referred to the Executive Committee.

### *Health of Foundry Workers*

On Friday, January 26, in the gymnasium of the Birmingham Accident Hospital, a discussion on this subject was opened by Mr. FitzHerbert Wright, Chairman of the Council of Iron Foundry Associations, who also showed a film on the work done in iron foundries. He was followed by Dr. G. F. Keatinge (Nottingham).

Mr. FitzHerbert Wright said that the casting of metal of all sorts, including gold and silver, had been carried out for ages. Iron itself was first worked as wrought iron and only later came to be cast. This opened up a tremendous field in the engineering world. Steam came along after and still further opened the floodgates of development in the foundry industry, followed by electricity and the internal combustion engine. In more recent years still, the foundry has spread its wings and entered on new fields such as the casting of steel, aluminium, brass, and the light alloys. However, the oldest application was iron which is still the most important of them all, because of its inherent stability and, to a certain extent, its cheapness of production.

Iron castings in some way or other are the basis of almost everything we use. At present there are about 1,750 iron foundries in this country; iron is responsible by weight for 2·5 million tons and steel for about 350,000 tons annually. The post-war demand is going to be greater, largely owing to the curtailment of civilian goods during the war, and an output of 3 to 3½ millions will be required. There are problems to be solved here, the most important one being labour. The foundry has, in the past, been an unattractive place to work in; dirty, and probably badly ventilated as well. This is where doctors can help, and the organized part of the industry is also doing its best to see that conditions are improved. Rates of pay are not bad, but in general youth does not as yet find attractive the prospect of a career in a foundry. An interesting book published by the Council of Iron Foundry Associations will shortly be available to show what a foundryman's life is like and will also show the educational facilities industry is putting forward and the big jobs that there are to be had. Dr. Keatinge will be dealing with special problems such as ventilation, heating and dusts, but by and large the foundry is not an unhealthy place in which to work.

The main processes in any foundry are: (1) melting of the metal; (2) preparation of the pattern; (3) preparation of the material which is to receive the metal—the moulds; (4) preparation of the material for the core and the making thereof; (5) pouring metal into the mould; (6) stripping and cleaning of fettling of the casting thereafter.

Careful control is required all the way through the

process if a good casting is to be achieved, not only of the metal but the sand or chills or permanent mould, whichever is to be used. Owing to the idiosyncrasies of draughtsmen and engineers, there will always be a field for jobbing foundries. Every designer who puts pencil to paper produces a new casting to suit his fancy. These appear all too often mere figments of an engineer's brain; they may be queer castings of which only one or two may be required. No proper equipment can be put in hand for the job and the success of it depends largely on the moulder's skill, in loam moulding especially. Fewer and fewer young moulders are coming on, and a great deal of standardization in the engineer's mind will have to take place if he still wants to obtain efficient castings. When a machine has to be mass-produced proper pattern equipment can be provided, the job can go into a mechanized foundry, and people can work with labour-saving plant. The plant can be worked by unskilled and semi-skilled people. This means a great deal of planning beforehand and careful control all the way through the process. In other words, a few highly-skilled technical men plan the job, produce designs and patterns, and provide the necessary supervision, the mass of work being carried through by their lesser skilled brothers. Industry is gradually developing on these lines, and this must increase more in this country if we are to survive. Our birth rate is falling, there are fewer pairs of hands, and our technical men must plan more and more for saving labour and time. So those who are the semi-skilled will then work under less arduous conditions and have shorter hours. They will be able to produce the same output in these shorter hours; and with more time for recreation they can then improve their minds and bodies, and so do much to relieve the monotony of their jobs. All this is a year or two ahead perhaps but it is certain to come.

## BIRMINGHAM GROUP

At a meeting on January 16th, Dr. E. H. Capel was elected honorary secretary of the group for 1945. Dr. Jean Mackintosh, senior assistant M.O.H., opened a discussion on ' Health Propaganda in Factories.'

Recently the Birmingham City Council had been considering the development of health education among adults, including post-school juveniles, and appointed a special sub-committee of the Health Committee to deal with the matter. The general range of work has been planned to include instruction in nutrition; personal and communal hygiene, including infectious and contagious disease and V.D.; the principles of healthy living, including sleep, rest, exercise, and the physiology of sex; and child care and parentcraft. A programme of this kind should have value and interest for factory personnel. It is felt that health propaganda in the factory should not be limited only to minimizing the hazards of work, but that it should be extended to include all aspects of health education. It is obvious that the worker's efficiency is influenced not only by the environmental conditions in the factory and his conduct while there, but also by the food he eats, by his home environment and the way he occupies his time when he is not at work in the factory. It is also desirable that he should have some knowledge of what the community does, to assist him in ways of healthy living. Some factory medical officers may feel that they themselves can cover the whole of this work, but there are no doubt others who would be glad to receive assistance from outside.

It was with a view to exploring the possibilities and arriving at some estimate of the need that Dr. Mackintosh sought an opportunity of meeting industrial medical officers working in this area.

## NOTTINGHAM GROUP

At a meeting on November 30, 1944, Dr. A. I. G. McLaughlin gave a demonstration of films and histological preparations of pneumokoniosis occurring in foundry workers. Films were shown demonstrating asbestosis and silicosis in various trades, pneumokoniosis of steel workers and coal miners, steel and iron foundry workers and sand moulders. Films were also shown of workers inhaling iron oxide in various occupations, to show the opacity of iron oxide to x-rays.

Dr. McLaughlin said that originally the word pneumokoniosis was used for lung diseases caused by dust. There were subdivisions, such as anthracosis, siderosis and silicosis to denote the dust concerned, i.e. coal, iron and silica respectively, but no distinction in their effects was recognized. Gradually it became apparent that one dust, silica, was far more injurious than others, and finally it was realized that when other dusts had apparently produced lung disease, this was due to the effects of silica in the dusts. Silicosis and asbestosis are probably the only true pneumokonioses, because the dusts of free silica ($SiO_2$) and asbestos both produce fibrosis of the lung. As far as is known, other dusts do not produce fibrosis. Silicosis is caused by breathing air containing the dust of free silica. It is characterized anatomically by generalized fibrotic changes and the development of miliary nodulation in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis and by characteristic x-ray changes. Asbestosis is caused by the dust of asbestos, the only silicate known to cause fibrosis of the lungs. Physical signs are usually those of a basal fibrosis. Asbestos fibres are not easily ingested by dust cells and removed to lymphoid tissue, but remain in contact with the air spaces and set up a fibrosis which begins about the terminal bronchioles. Silico-anthracosis is due to deposits of mixed dusts containing coal and free silica in similar positions. A definite fibrosis develops as in silicosis. The term siderosis should not denote fibrosis of the lungs due to iron dust. Pure iron oxide does not set up a fibrotic reaction. Fibrosis may occur when the iron dust is mixed with silica and the condition may then be known as siderofibrosis (as in fibrosis of boiler scalers). All dusts inhaled and retained in the lungs of workers are deposited in the lymph channels and stations—usually peribronchial, perivascular, glandular and subpleural. This accounts for similarity of x-ray appearances in the dust pneumokonioses. In some cases abnormal x-ray shadows are thrown by areas of fibrosis and congestion, in others the shadows are due to the fact that the dust aggregates are opaque to x-rays. Opacity to x-rays depends on the atomic weight of the element.

A meeting took place on January 11, 1945. Dr. J. C. Bridge took the chair on the invitation of the group chairman, Dr. T. A. Lloyd Davies. A description of the R.A.F. Rehabilitation Unit was given by Group Captain C. J. S. O'Malley and Squadron-Leader Zinovieff, who were introduced to the meeting by Dr. Bridge.

Group Captain O'Malley sketched the development of surgical rehabilitation in this country, paying tribute to the work of such pioneers as the late Sir Robert Jones, Harold E. Moore, Alexander Miller, H. E. Griffiths and E. A. Nicoll. The first beginnings of the R.A.F. Rehabilitation Unit were at the R.A.F. Officers' Hospital, Torquay, in 1940, and centres for other ranks were at Hoylake and Blackpool. When the hospital at Torquay was bombed and most of the skilled personnel were lost, a Unit was formed at Loughborough. Rehabilitation should start in hospital and finish at the rehabilitation centre, the atmosphere of which should inculcate the will to get better; the body-mind needed treatment; in fact the injured person should be dealt with as a whole. The Loughborough Rehabilitation Centre is not a hospital; it is run largely as a club with a benevolent autocracy at the top. It is important that the environment should be of a kind to which the man is accustomed. Cases arrive at the unit as soon as they are fit to move from hospital: fractures, when the patient is in an unpadded plaster; and soft tissue injuries, when the stitches have been removed. Great importance is attached to the reception of the patient who is made to feel at home from the first moment of arrival.

Elimination of self-pity is the primary principle, and in order to do this excessive sympathy with the man is avoided. Boredom and monotony are removed by evening programmes, such as films, dances, debates following talks by well known public people, and talks by the patients themselves on any subject they please for twenty minutes. Many of the patients are frightened to get well because this will involve a return to the environment which caused the trouble. This is especially true of the officer air crew; so pilots, observers, gunners and wireless operators are all given their own kind of work to do as soon as fit for it. Thus pilots use the Link Trainer, air gunners use power-operated turrets and also the rifle range and they are encouraged in clay pigeon shooting. Fitters work on the actual machines on which work will subsequently be done, e.g. the air frame fitter works on an actual fuselage. Occupational therapy is given to those not yet fit to undertake more advanced work. Clay modelling is useful for burnt hands. Weaving is not used as it is completely divorced from reality. An actual factory at which men work is established at East Grinstead in which a time study of programme of work was given as 40,000 hours. The work was actually performed by these injured men in 19,000 hours. Ninety-two per cent. of officers passing through the unit went back to flying duties and 64 per cent. to operational flying. Eighty-four per cent. of other ranks went back to their trades.

Squadron-Leader Zinovieff stated that everything possible is done to ensure the co-operation of the patient. Thus the objective to be achieved is explained to him and the patient is personally introduced to the physiotherapist or PT instructor who would be treating the case. Physiotherapy is important but should not be made to appear so to the patient. Active movements on his own part are much more important. In order to emphasize this point of view the physiotherapy department is known as the Early Mobilisation Room. There is continuous supervision by the medical officers of the actual treatment of patients. The programme is varied so as to prevent boredom and arranged so as to suit each individual problem. The treatment depends on the working of the medical personnel of the team; the medical officer gets to know each patient intimately and the physiotherapists and PT instructors are taught the proper approach to the patient and provide a routine report on their cases weekly. Every member of the team requires to have a suitable personality. A PT officer acts as liaison between the medical and PT departments. In general the early cases are treated by physiotherapists aided by rehabilitation orderlies; in the intermediate stage, partly by physiotherapists and partly by PT instructors, and in the advanced stages by PT instructors only. A swimming bath is an essential feature of a rehabilitation centre for swimming constitutes the best non-weight bearing exercise there is. Cases are divided into anatomical groups: (1) *Arms*—shoulders, elbows, wrists, hands; (2) *Legs*—femur, ankles and feet, tibia and fibula, knee joints; (3) *Spines*, and (4) *Multiple injuries*. A very complete dossier of each patient's case comes to the centre from the hospital where he was treated and in it are full notes and reduced prints of x-rays relevant to the case. Notes are kept at the rehabilitation unit and a secretary is needed for this work so that the medical officer can devote to the patients the time that he would otherwise spend in clerical work.

## SCOTTISH GROUP

At a meeting held at the University of Glasgow on January 24, 1944, with Dr. Harry M. Roberts in the chair, Professor T. Ferguson read a paper on 'The Resettlement of Disabled Persons in Industry.'

Many factors influence the successful resettlement in work of disabled men. The attitude of employers is important, and especially of their foremen, who can do so much to make or mar success: so too is the attitude of work-mates—who sometimes grow weary of the little extra help that may make all the difference—and the attitude and adaptability of the disabled men themselves. The problems raised by compensation in cases of injury are often a hindrance to resettlement. Again, light work within the industry in which a disabled man was employed prior to his incapacity may be a legitimate, and indeed the most satisfactory, method of restoring him to full fitness for work, but safeguards are necessary to prevent abuse of light work in this connexion and to see that the man is not allowed to drift along indefinitely in light work if he is, in fact, able to do something better. The future of the severely disabled man is so much in the balance that anything that makes him even a little more efficient adds enormously to his prospect of successful resettlement: it is therefore important to secure the highest possible measure of physical and psychological repair. Generally speaking, the longer disability has been present the less satisfactory the prognosis; and age, too, is important. Experience in Denmark has been to the effect that it is rarely an economic proposition to embark on the training in new work of a disabled man over the age of 35 years and recent experience in this country certainly confirms that, in general, younger men do best in relation to training for new employment. The care of the disabled should be set afoot as early as possible, and the notification experience of Denmark is worthy of further study.

Geographical considerations may be weighty. Sometimes the nature of the district in which the disabled man lives does not offer much scope for new employment either because of the unrelieved heavy industry in it or because of isolated situation with limited facilities for employment. In Scotland, it is not easy to find suitable work for disabled men in some areas of Lanarkshire, or in some of the more remote parts of the Highlands. The previous industrial experience of the disabled man is of great importance and so is the possibility of harnessing such industrial knowledge or background as he may have to new work. For instance, a man may be unable to follow his trade as a woodworker, but if he can be given a certain amount of commercial training and this related to his basic knowledge of the woodworking industry, then he may become a very valuable agent, despite his disability. In the presence of serious disability it is often of substantial help to secure the return of the disabled man to an industrial environment with which he is familiar; if possible, even to the factory in which he was formerly employed.

Disabled men encounter many difficulties, with medical, social, and employment aspects closely interwoven. Some find their work too heavy; some that long travelling to and from work after a long working shift is too much for them; some have difficulty in obtaining tools; some have difficulty in obtaining suitable clothing. Many have financial troubles; the wages they are able to earn are often too low for their responsibilities. Many chafe at what they think are irksome pension delays. Many have difficulty in getting a suitable house: a disabled man may have almost as much difficulty in making his way up and down the stairs of a high tenement house as in doing his day's work. To be successful the approach to the problems of disability must be along individual lines, and the disabled man must be kept in view until it is clearly established that he is indeed settled in work within his compass.

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